Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

010 EMPIRE BUILDING | December, 1944 | PITTSBURGH, PA.

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DETROIT
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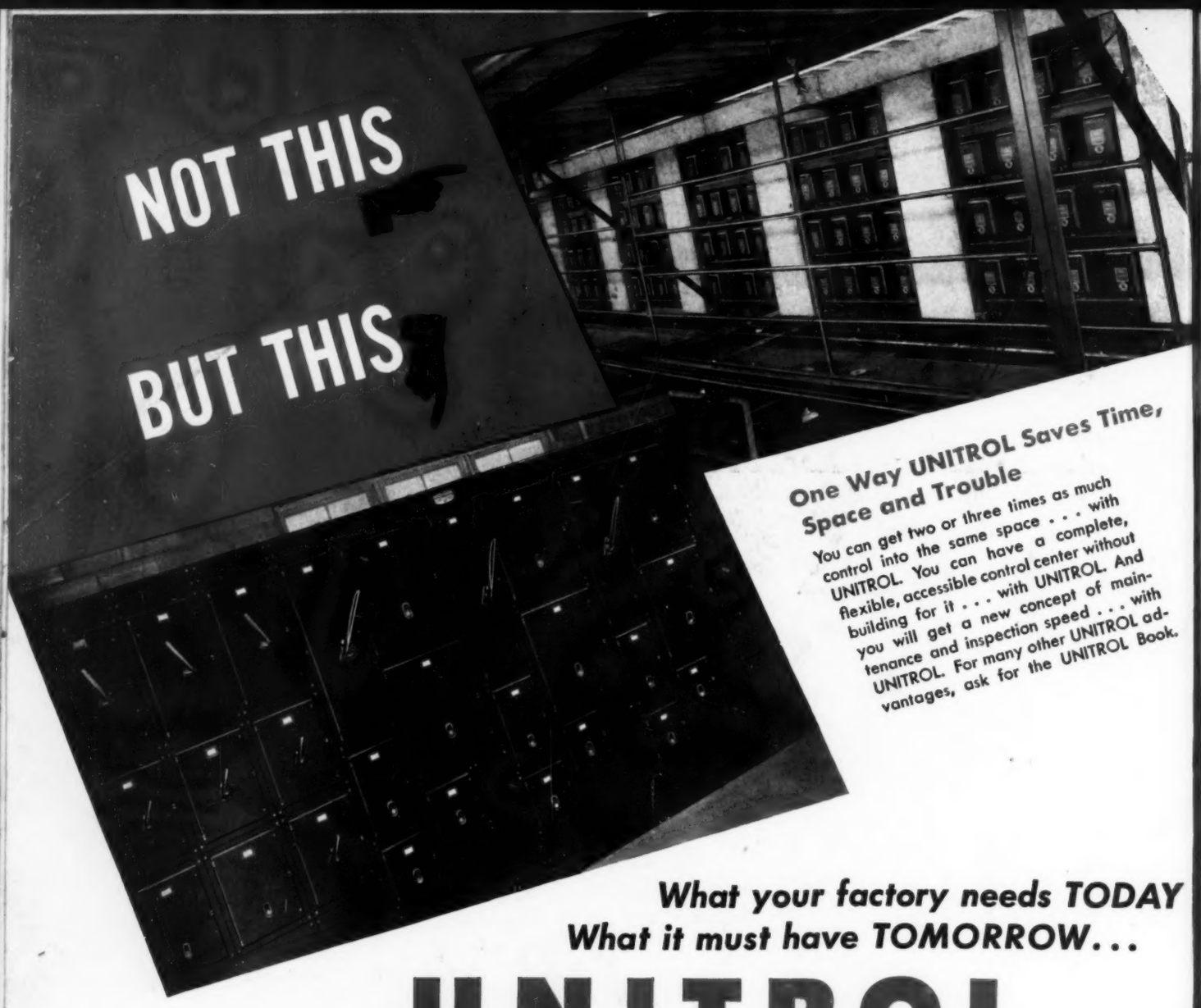
You will find it on the Rolls in Mills which have a Reputation for Quality plus Tonnage

LEWIS FOUNDRY & MACHINE DIVISION
of BLAW-KNOX Company
Pittsburgh, Pa.

ARMY NAVY

Also manufacturers of ROLLING MILL MACHINERY for the iron, steel and non-ferrous industries

LEWIS ROLLS



One Way UNITROL Saves Time, Space and Trouble

You can get two or three times as much control into the same space . . . with UNITROL. You can have a complete, flexible, accessible control center without building for it . . . with UNITROL. And you will get a new concept of maintenance and inspection speed . . . with UNITROL. For many other UNITROL advantages, ask for the UNITROL Book.

What your factory needs TODAY
What it must have TOMORROW...

UNITROL

● Wondering what you can do about more plant space? Wondering how to get more work out of an already overburdened electrical maintenance crew? Wondering how to be best prepared for the production layout your plant will require tomorrow? UNITROL can contribute a great deal to the solution of these and many other vexing production, design and maintenance problems. UNITROL may disclose important space you didn't know you had. UNITROL can lift a big load off the shoulders of harried, hurried electrical men. UNITROL will help you to many short cuts in shifting, changing, replacing or rebuilding your plants' motor control facilities in line with changing needs. If you don't know *all about* this pioneering, unitized, sectionalized method of mounting, housing and centralizing motor control, a request for the UNITROL Book should be your first order of business. Many of today's leading plants say UNITROL is the next step forward in modern motor control practice; the UNITROL Book has a wealth of time, money and work saving ideas. Send for a copy today . . . CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wisconsin. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

CUTLER-HAMMER
UNITROL
C-H

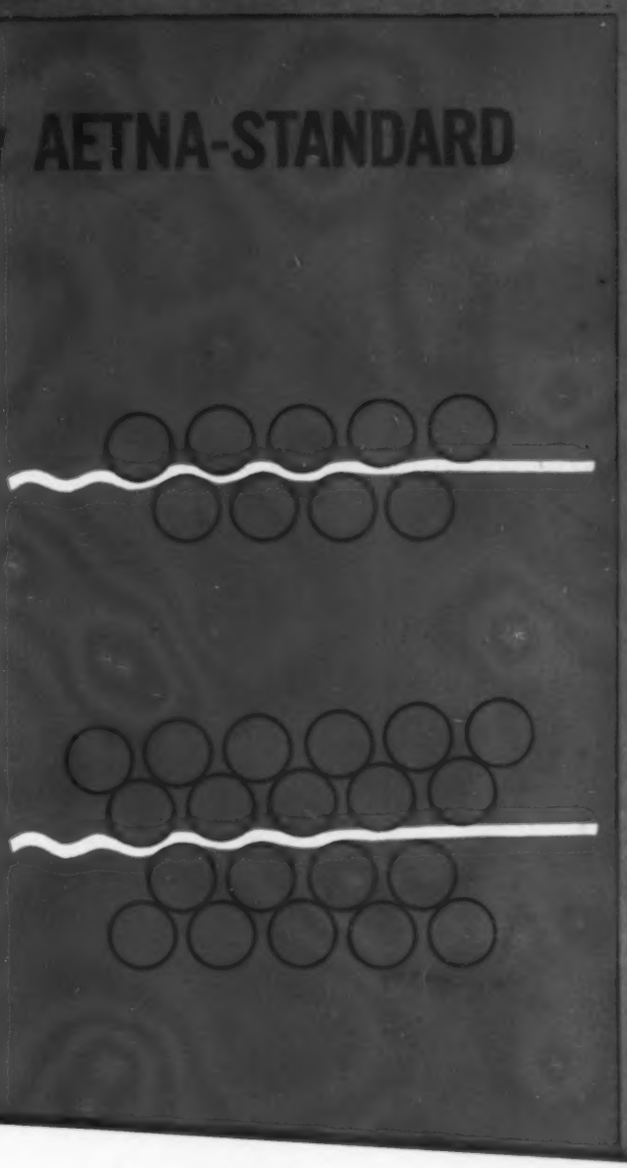
Copyright 1944, Cutler-Hammer, Inc.

UNITROL and your filing cabinet system have much in common

You can easily change the contents in any drawer of your filing cabinets. You can easily add, subtract or change sections. And you can easily go from one drawer to another. UNITROL is that kind of a cabinet filing system for Motor Control . . . its value to *any* plant already proved in *hundreds* of plants

Engineering Excellence Finds its Greatest Reward in the Respect and Confidence of those it Serves

Performance Record by AETNA-STANDARD on LEVELLERS

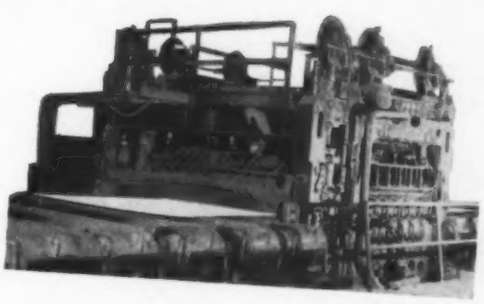


Aetna-Standard can manufacture any size or type of 2-high or 4-high leveller for any weight or type of ferrous and non-ferrous material.

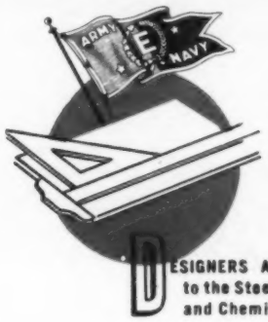
1¾″	diameter	rolls	x 41″ to 60″ wide, Backed up
2½″	″	″	x 54″ to 102″ wide, Backed up
2⅞″	″	″	x 36″ to 48″ wide, Two high
3½″	″	″	x 54″ to 102″ wide, Backed up
3¾″	″	″	x 48″ to 72″ wide, Two high
4½″	″	″	x 48″ to 72″ wide, Two high
4½″	″	″	x 60″ to 90″ wide, Backed up
5¼″	″	″	x 54″ to 90″ wide, Two high
7″	″	″	x 60″ to 84″ wide, Two high
9″	″	″	x 72″ to 110″ wide, Two high
12″	″	″	x 140″ wide, Two high
14″	″	″	x 110″ wide, Two high
18″	″	″	x 140″ wide, Two high

Several factors influence the selection of a 2-high or 4-high leveller . . . size of material, kind of material, how material is to be processed, capacity and future requirements.

Aetna-Standard engineers, experienced in all types of mills and mill equipment, can give you many profitable tips. They have designed and installed many hundreds of levellers for both ferrous and non-ferrous production.



A 12′ x 140′ plate leveller, designed, built, and installed in record time by Aetna-Standard, for processing ship plates. The levellers flatten hot, heavy, alloy plates as fast as they come from the rolling mill . . . 100 to 300 feet per minute.



DESIGNERS AND BUILDERS to the Steel, Non-Ferrous and Chemical Industries

THE AETNA•STANDARD ENGINEERING COMPANY

YOUNGSTOWN, OHIO

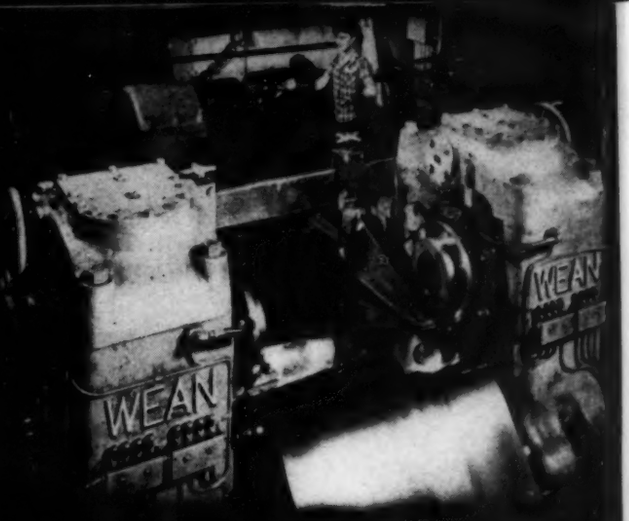
ASSOCIATED COMPANIES:

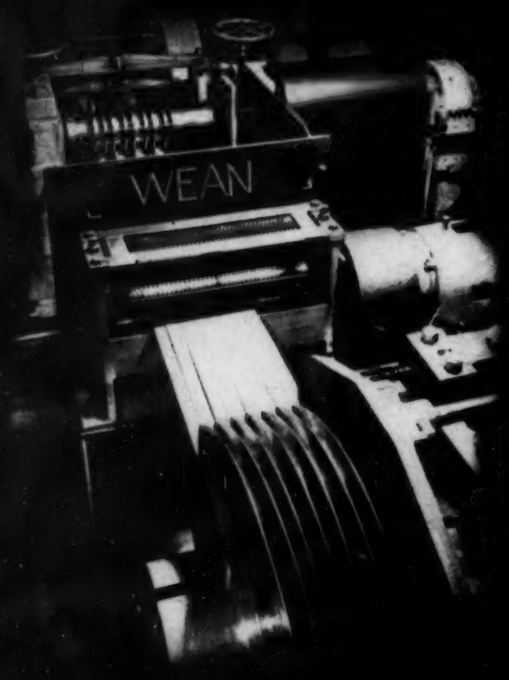
HEAD, WRIGHTSON & COMPANY, LIMITED, THORNABY-ON-TEES, ENGLAND

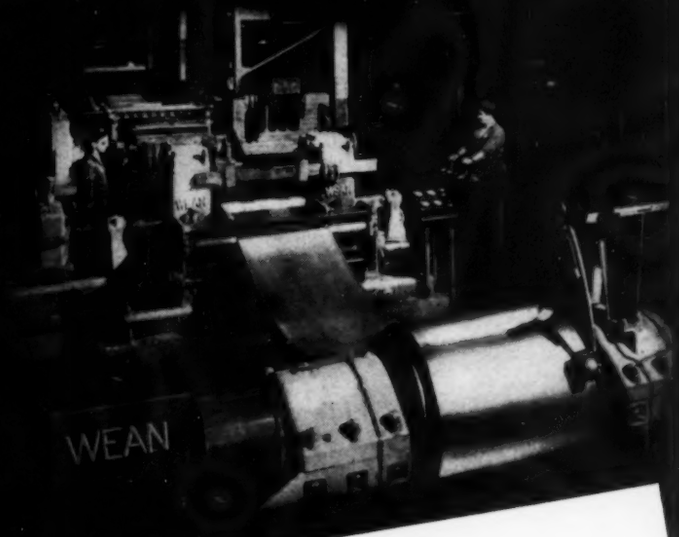
JOHN INGLIS COMPANY, LIMITED, TORONTO, ONTARIO, CANADA

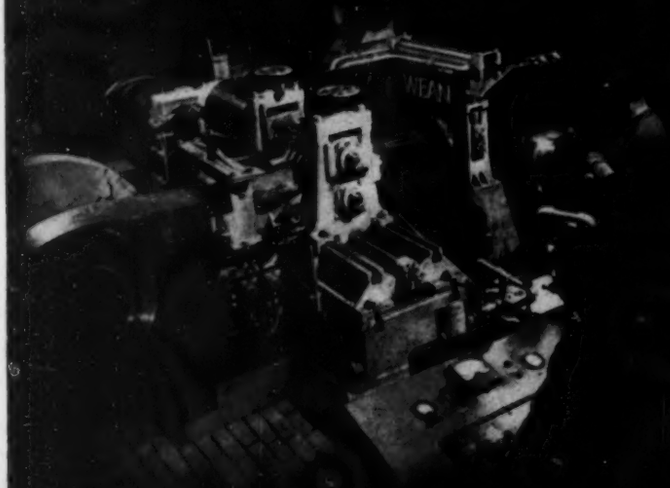
WEAN

SHEARING, SIDE TRIMMING AND SLITTING EQUIPMENT *for* STRIP STEEL



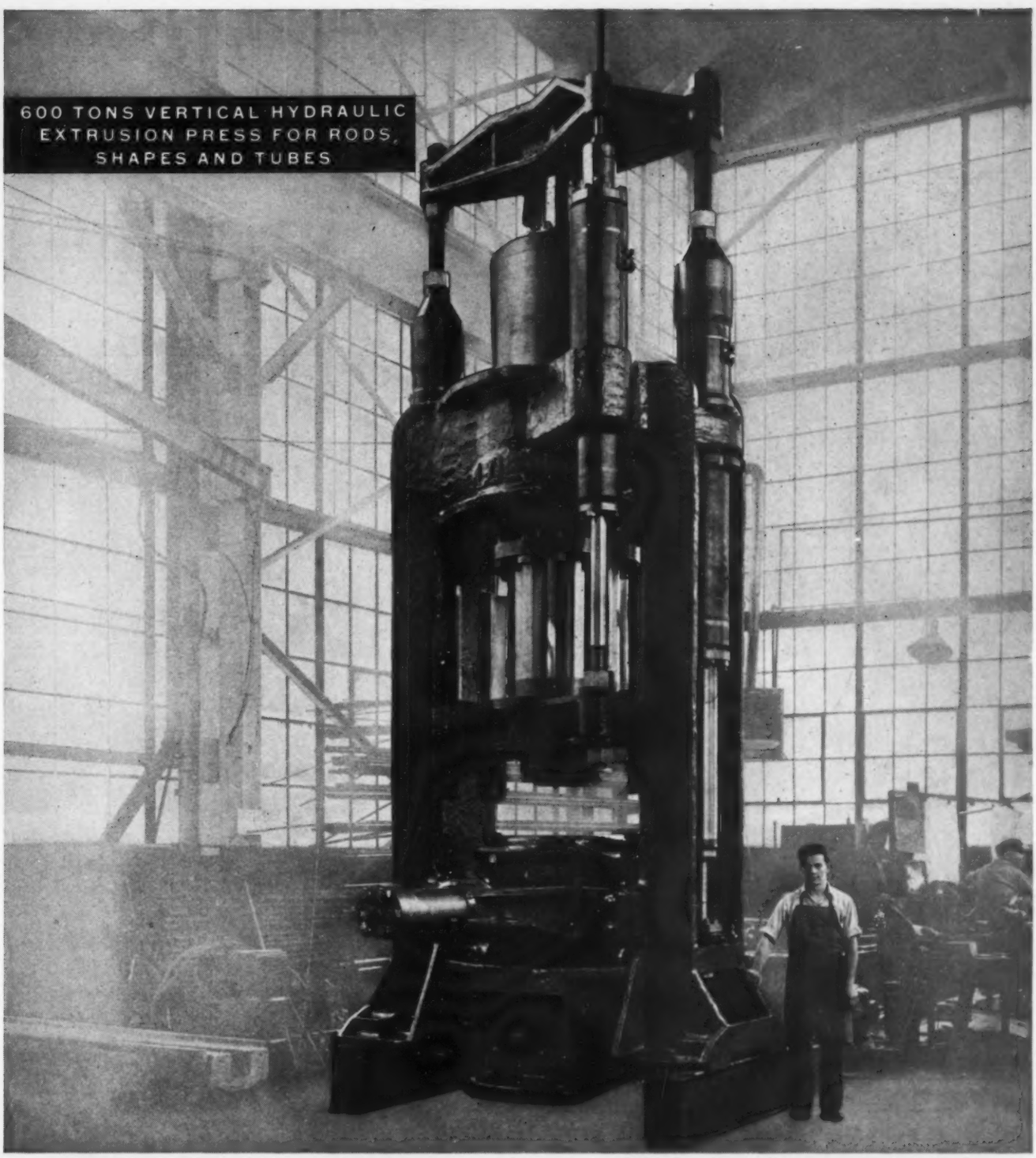






THE WEAN ENGINEERING CO., INC.
WARREN, OHIO

SPECIALISTS IN SHEET, STRIP AND TIN MILL EQUIPMENT



HYDROPRESS · INC.

ENGINEERS CONTRACTORS

HYDRAULIC PRESSES · ROLLING MILLS
STRETCHERS · PUMPS · ACCUMULATORS

570 LEXINGTON AVENUE · NEW YORK · N. Y.

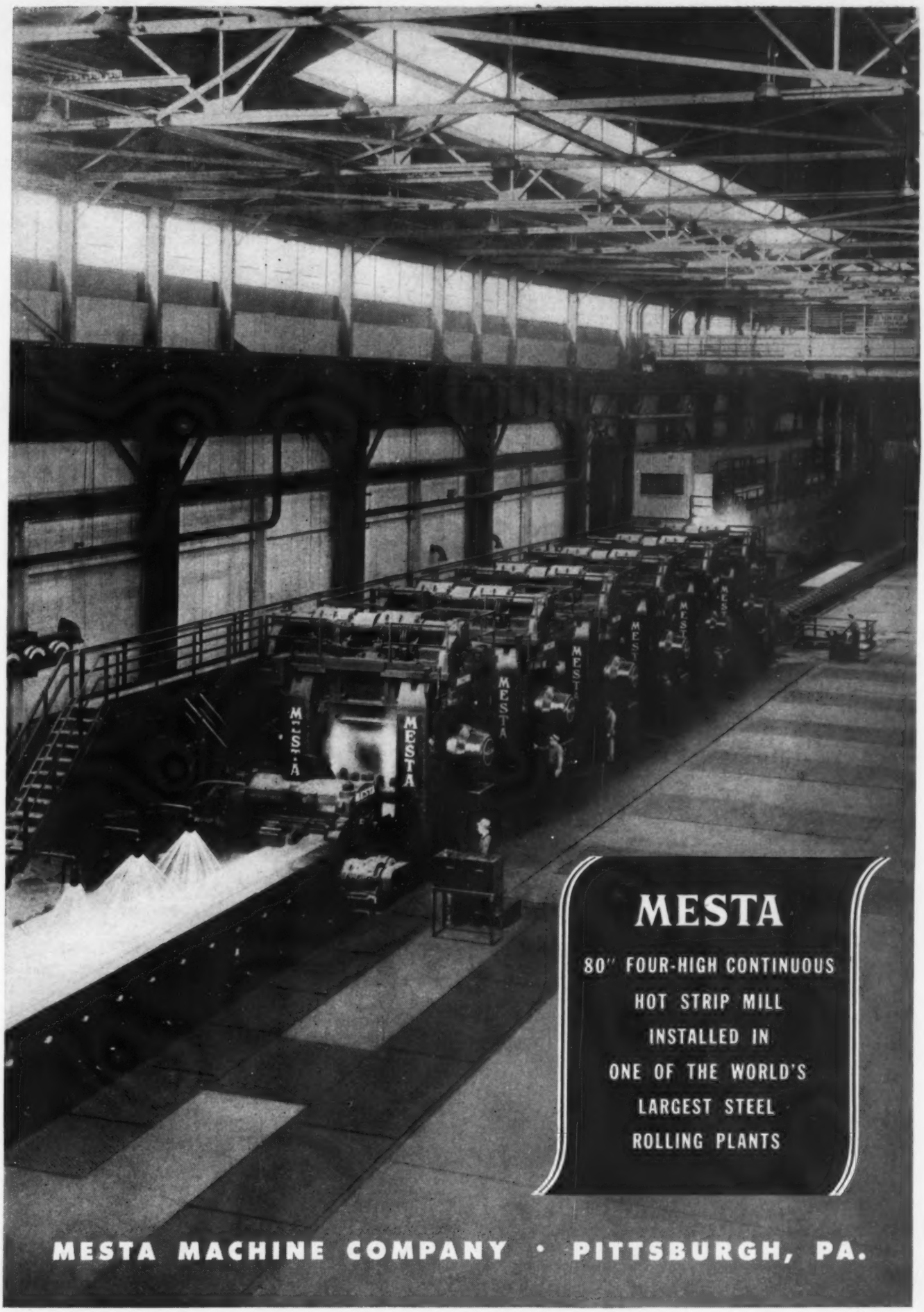
the Birth of the World's Greatest Navy

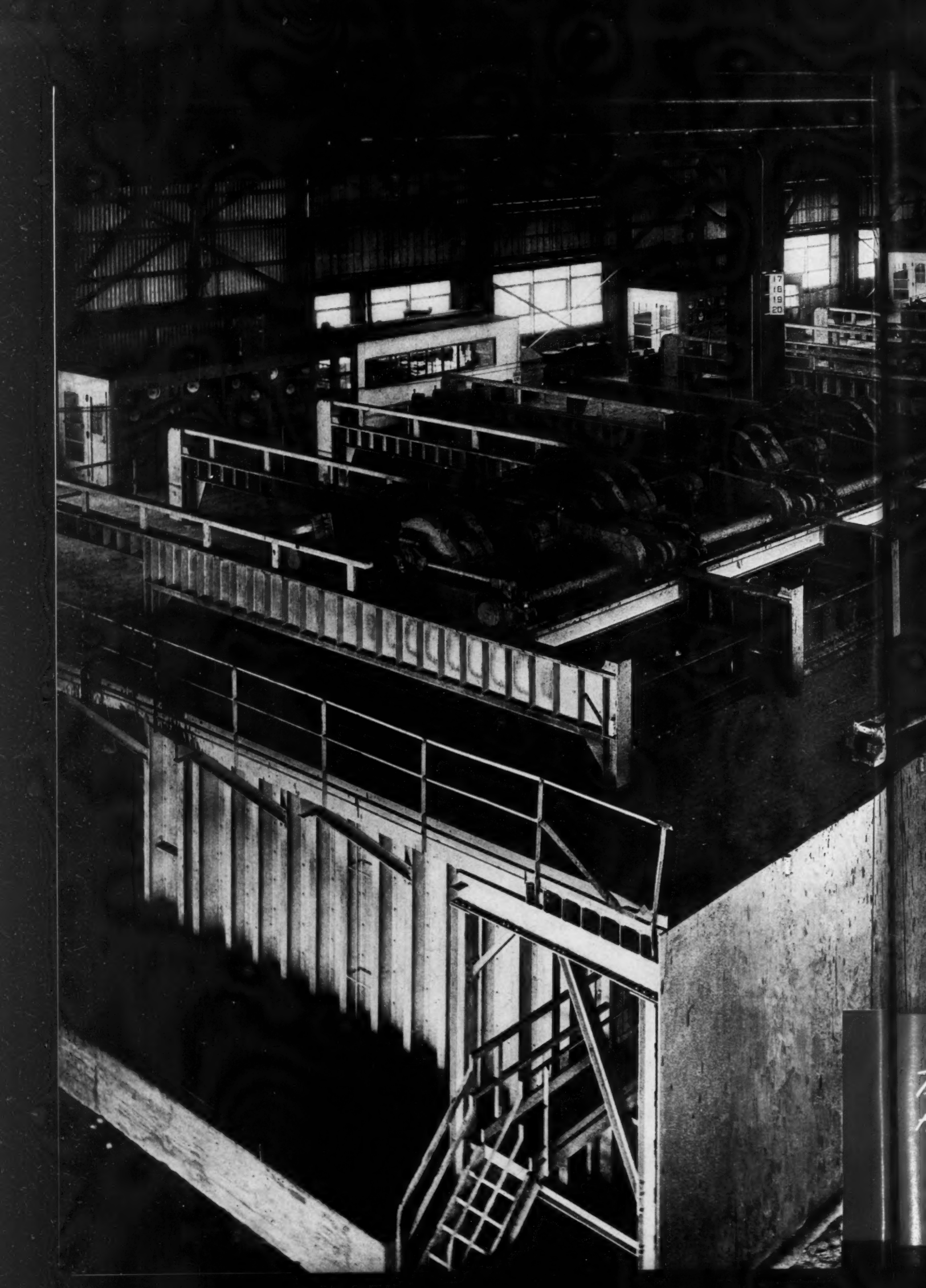
PEARL HARBOR is a symbol of American bounce. Pearl Harbor December 7, 1941 came as a shock to the nation. Our Pacific fleet, gathered in one harbor, lay helpless under the wings of Japanese treachery.

But from that catastrophe has arisen the mightiest fleet of all history. Sunken, fire-blackened hulks were raised and their weaknesses converted to strength. Pearl Harbor ships, reconditioned in record speed, are mightier than ever. And from the ways of Navy Yards and shipyards all over the United States has come a fleet greater than all other navies of the world combined.

For over half a century Okonite has been a Navy supplier of electrical wires and cables. Okonite research men, cooperating with Navy engineers, pioneered such recent improvements as the synthetic impervious sheath that eliminates heavy coverings of lead, glass fibre insulation that resists heat, flameproof synthetic insulations that replaced rubber, "unilay" assembly of conductors that prevented breakage of copper in flexible cables and Okoloy corrosion-resistant coatings for conductors.

We are justifiably proud of our many contributions that have improved the distribution of electrical power in the ships of our Navy. These same improvements have been incorporated in other cable designs used for power and lighting applications in many other industries. The Okonite Company, Passaic, New Jersey.


MESTA
80" FOUR-HIGH CONTINUOUS
HOT STRIP MILL
INSTALLED IN
ONE OF THE WORLD'S
LARGEST STEEL
ROLLING PLANTS
MESTA MACHINE COMPANY · PITTSBURGH, PA.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18
19
20

'Surface' ONE-WAY FIRED Pits

IN THE WORLD'S LARGEST ELECTRIC ALLOY STEEL PLANT

● Every feature of modern pit construction has been "Surface" engineered into this installation to provide for *quantity* and *quality* tonnage.

Not only is it large in the number of pits (24), but each pit ranks in individual size—2,800 cubic feet. Electric steel ingots ranging in size from 10,000 to 34,000 lbs. each, are being uniformly heated in a minimum of time. The total installed capacity is approximately 2,000 tons.

To maintain the constant high quality of the electric alloy steel a "Program Control", including automatic temperature and combustion controls, has been installed for each individual pit.

All of these unique features provide for the utmost in flexibility.

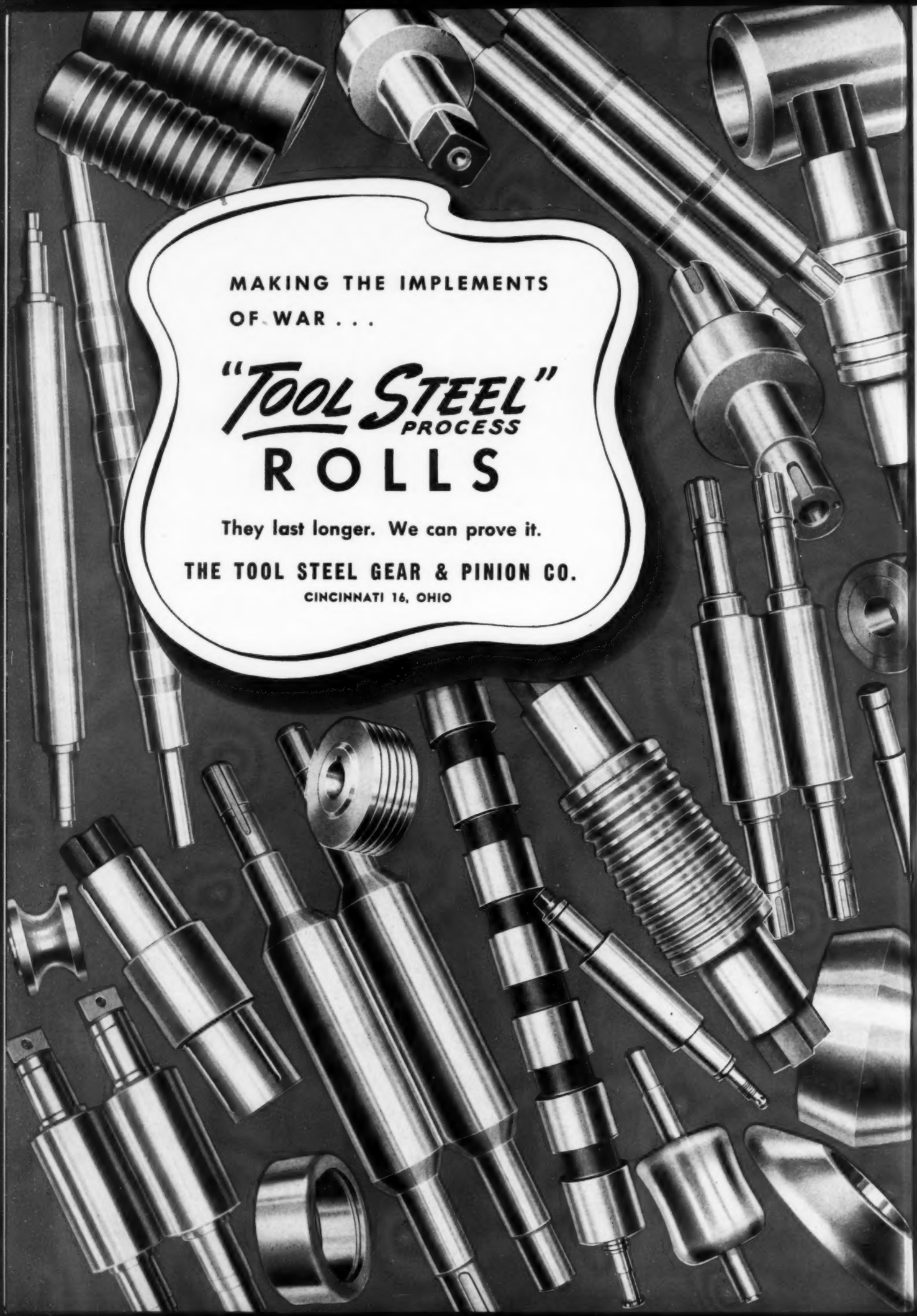
"Surface" Engineers are alert to designs and methods that give the simplest in construction; greatest capacity; most efficient firing; best heat distribution and lowest maintenance. That's the reason for the decided trend to modern "Surface" One-Way Fired Pits . . . 145 since 1936! . . . 93 since 1941—when quality and *quantity* tonnage really counted.

The Heater's and Heat Treater's Helping Hand

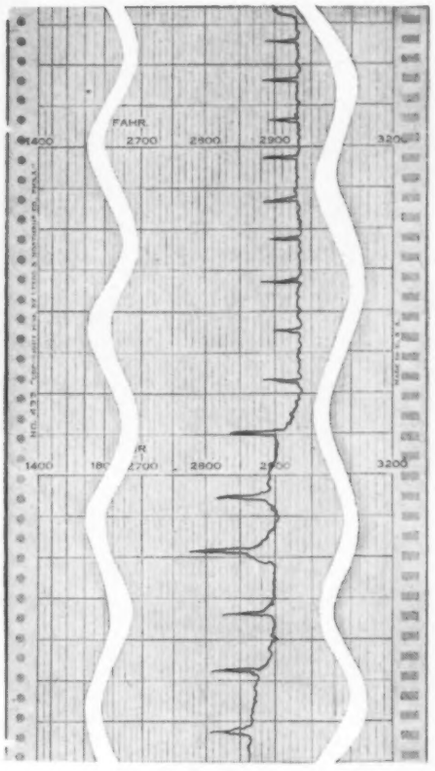
'Surface'

SURFACE COMBUSTION • TOLEDO 1, OHIO

"WHEREVER HEAT IS USED IN INDUSTRY ...FROM INGOT TO FINISHED PRODUCT"


MAKING THE IMPLEMENTS
OF WAR . . .
"TOOL STEEL" PROCESS
ROLLS
They last longer. We can prove it.
THE TOOL STEEL GEAR & PINION CO.
CINCINNATI 16, OHIO

First Helper in open-hearth shop of Erie Forge Company looks at Micromax Roof-Temperature Controller, which enabled him to set record of 400 melts in one campaign for furnace shown below.



Typical record, reduced, of Micromax Roof-Temperature Controller shown at left. Chart dips show points at which the Controller cut off oil fuel to prevent overheating roof.

O-H CAMPAIGN MAKES 400 HEATS As MICROMAX Control Saves the Roof

Over 400 melts of high-alloy open-hearth forging steel (far above the best previous record) were produced in the first campaign after the furnace above was equipped with L&N Control for roof temperature, combustion and reversal. This unit is one of three 65-ton o-h furnaces in the plant of Erie Forge Co., makers of heavy steel castings, forgings and forging ingot. All furnaces now have identical controls, as a result of the controller's performance on the one shown.

Erie Forge executives give the Micromax Roof Temperature Controller, which is just one element of the complete Control, full credit for saving the furnace roof and enabling the campaign to be extended so long, especially when making alloy steel with its long heats at high temperature.

But production men also point out that the stoppage of checkers, due to tar and dust, during so long a campaign, would have forced the furnace to shut down much earlier than it did, except for the automatic Combustion Control of fuel, air and furnace pressure.

And the very base of success of all operation, the Erie men feel, is the Micromax Automatic Reversal, which reverses the flow through the checkers on the basis of their temperature, and so levels out the operating and gives the other controllers a chance to be of greatest effectiveness.

If you have a specific problem in open-hearth control, an L&N engineer will be glad to work with you on it.

Micromax Roof-Temperature Control kept this 65-ton acid open-hearth furnace in operating condition for over 400 melts. Even then, roof was O.K., but checkers were so choked (note sting at doors) that rebuild was necessary.

Jrl Ad N-33B-643(2)

LEEDS & NORTHRUP COMPANY, 4942 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

* UNIFORMITY

TIDE WATER LUBRICANIA

DEFINITION: The uniformity of a lubricant is generally understood to mean the conformity in certain specified essential qualities between two or more separate "lots", "batches", or drums of lubricant.

EXPLANATION: In general a slight variation between drums of lubricant in one or more qualities — carbon residue, pour point, specific gravity, etc. — may not have any noticeable effect on the performance of the lubricant. However, if there is a variation in more than one quality — or if the variation occurs in a quality that has a critical bearing on a specific service for which the lubricant is used (i.e., Demulsibility of Steam Cylinder Oils) — then a serious variation in lubricant performance is likely to result.

TEST: There is no single test that can be made to determine uniformity. In practice, each "batch" of lubricant must conform to certain prescribed test limits. The lubricant is tested for certain specific qualities, depending on the service in which it is to be used. Tests may be made for Viscosity, Flash Point, Carbon Residue, Pour Point, Neutralization Number, Penetration, Specific Gravity, Color, or any other pertinent factors.

CONCLUSION: Most reputable refiners and marketers of lubricating oils, greases, and compounds recognize the extreme importance of maintaining uniformity. For this reason their entire manufacturing and testing procedure is scientifically conducted and strictly controlled. Regular testing by skilled technicians, using modern test equipment, provides a further means of assuring the continuing uniformity of each specific lubricant.

INDUSTRIAL TYCOL OILS-GREASES

GASOLINE POWERS THE ATTACK — DON'T WASTE A DROP

SCIENTIFICALLY ENGINEERED FOR EVERY INDUSTRIAL USE **TYCOL**

This is the 13th of a series of informative messages concerning the meaning and significance of commonly used tests and terms employed to describe the characteristics of lubricating oils.

INDUSTRY'S widespread preference for Tycol oils and greases results in part from their unquestioned uniformity within each classification — from the first drum to the thousandth. Equally important is the skill with which they are engineered to meet the specific requirements of each type of service.

Whatever your lubricating need, there is a Tycol lubricant that will do the job with uniformly satisfactory results. Let a Tide Water engineer help you select the best one for your particular need. Call or write any Tide Water office for further details.

DRUMS! DRUMS! DRUMS!
War needs make it extremely important that all empty drums be returned immediately.

TIDE WATER ASSOCIATED OIL COMPANY

MAKERS OF THE FAMOUS VEEDOL MOTOR OIL • Eastern Division: 17 Battery Place, New York 4, N. Y.

Principal Branch Offices: Boston, Philadelphia, Pittsburgh, Charlotte, N. C.

INDUSTRIAL LUBRICANTS

Above: Controls of this 125-ton Beloit Crankpin Turning Lathe are grouped within easy reach of operator.

As shown at right, Reliance V★S Drive is also available with a "packaged" control unit, to provide smooth speed changes over wide ranges.

Above: The built-in Reliance V★S Adjustable-speed Drive furnishes controlled power for all functions from A-c. circuit.

GIANT LATHE OPERATES FROM A-C POWER LINES

With All Operations Electrically Controlled Through Reliance V★S Drive

In doing its job of machining the huge crankshafts for Diesel Engines, this 125-ton Beloit Crankpin Turning Lathe combines an exceptionally high rate of production with precision operation. This is due in no small measure to the use of Reliance V★S Drive.

All operations—starting, stopping, jogging, reversing, speed adjustments—are electrically controlled, using the plant's A-c. lines. All controls are within convenient reach of the operator. Both design and operation of the machine are greatly simplified.

This is but one example of the way in which, with Reliance V★S Adjustable-speed Drive, it is possible to centralize and simplify control of complicated production machines and operations. It is something you are likely to find worth talking over with a Reliance Application Engineer. Or write us at Cleveland for more information if that is more convenient.

RELIANCE ELECTRIC & ENGINEERING CO.

1088 Ivanhoe Road • Cleveland 10, Ohio

Birmingham • Boston • Buffalo • Chicago • Cincinnati • Detroit • Greenville (S. C.) • Houston • Kalamazoo • Los Angeles • Minneapolis New York • Philadelphia • Pittsburgh • Portland (Ore.) • St. Louis • San Francisco • Syracuse • Washington, D.C. • and other principal cities.

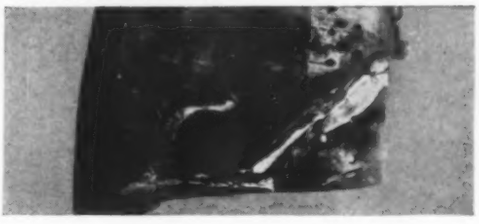
RELIANCE A-C D-C MOTORS

TESTED CURES

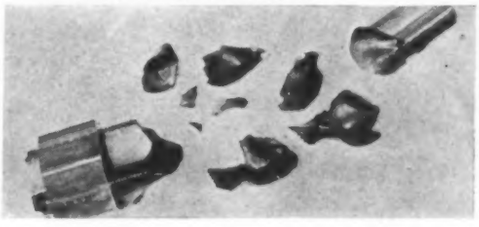
for mill maintenance headaches

Case No. 1843: Cast iron piston head from blooming mill engine being brazed over worn surface with manganese bronze. This operation triples life of cylinder before reboring is required.

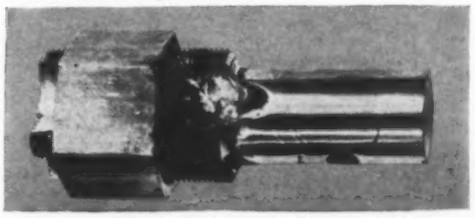
Case No. 2314: Part of broken base from a 60-year old steam engine. Gouged out breaks were repaired by brazing with Airco No. 22 manganese bronze. Engine restored to service in 10 days.



Case No. 3782: This tap appeared to be a total loss until low temperature brazing was employed in its repair. Using Easy-Flo brazing alloy the tool was successfully salvaged. (See below)



View of the reclaimed tap after brazing and before final machining. Many other cutting tools may be salvaged by low temperature brazing—often at remarkable savings in cost.



IF you are having "maintenance headaches" due to today's serious problems of wear and repair, try these tested methods that many mills are now using successfully. These modern welding procedures are not merely "stop-gap" measures—in many cases their economy and efficiency has made them accepted maintenance methods for both war and peacetime.

By specifying Airco welding rods, electrodes, fluxes and other Airco "job-tested" supplies, you can assure the most satisfactory results on your repair jobs. Airco's Field Engineering Service will be glad to assist you in the selection and use of the proper procedure and materials for each job. Call or write your nearest Airco office for full details.

An informative booklet "Welding Aids Mill Maintenance" will be furnished free on request. Write to Dept. IS at the New York address.

★ BUY UNITED STATES WAR BONDS ★

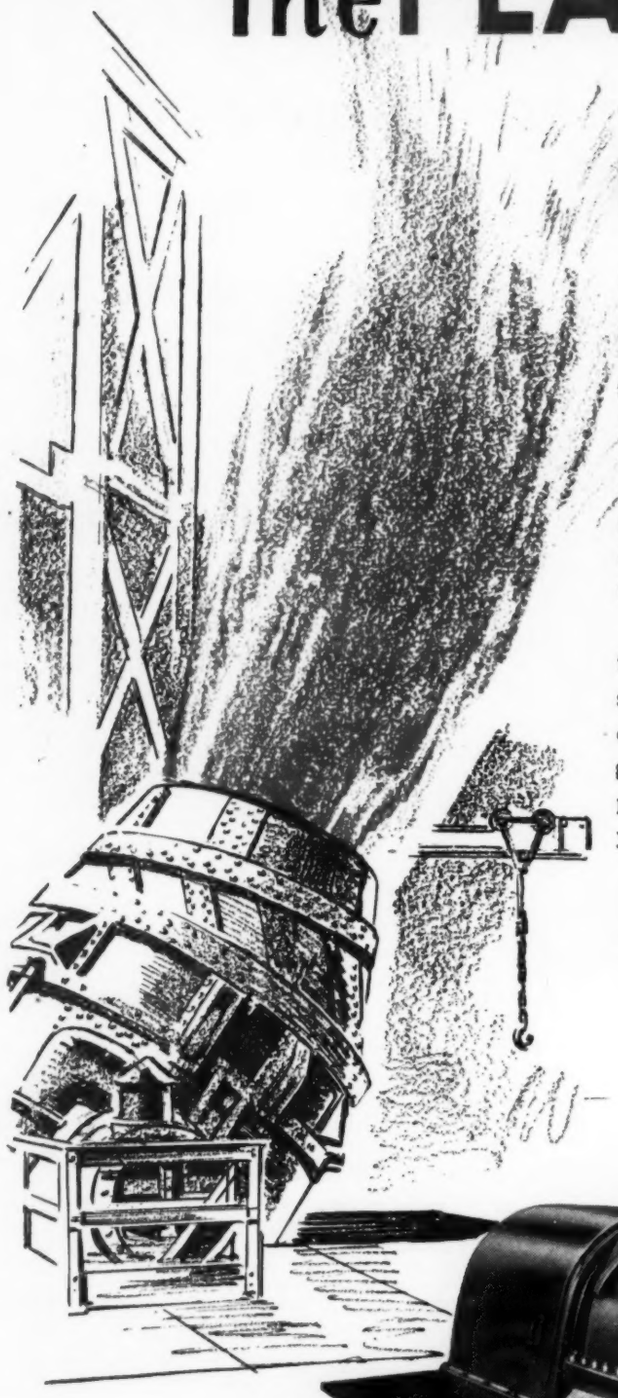
AIR REDUCTION

General Offices: 60 EAST 42nd STREET, NEW YORK 17, N. Y.

In Texas: MAGNOLIA AIRCO GAS PRODUCTS CO. • General Offices: HOUSTON 1, TEXAS

Offices in all Principal Cities

The FLAME of PURITY



Sir Henry Bessemer's brilliant demonstration . . . that molten pig iron could be transformed directly into steel by a blast of air . . . paved the way for much of our present-day industrial growth.

In Bessemer's converter, a blast of compressed air blown through the molten iron burns out the excess carbon, silicon and manganese. Because this purification is a combustion process, the metal *remains* molten without the addition of external heat.

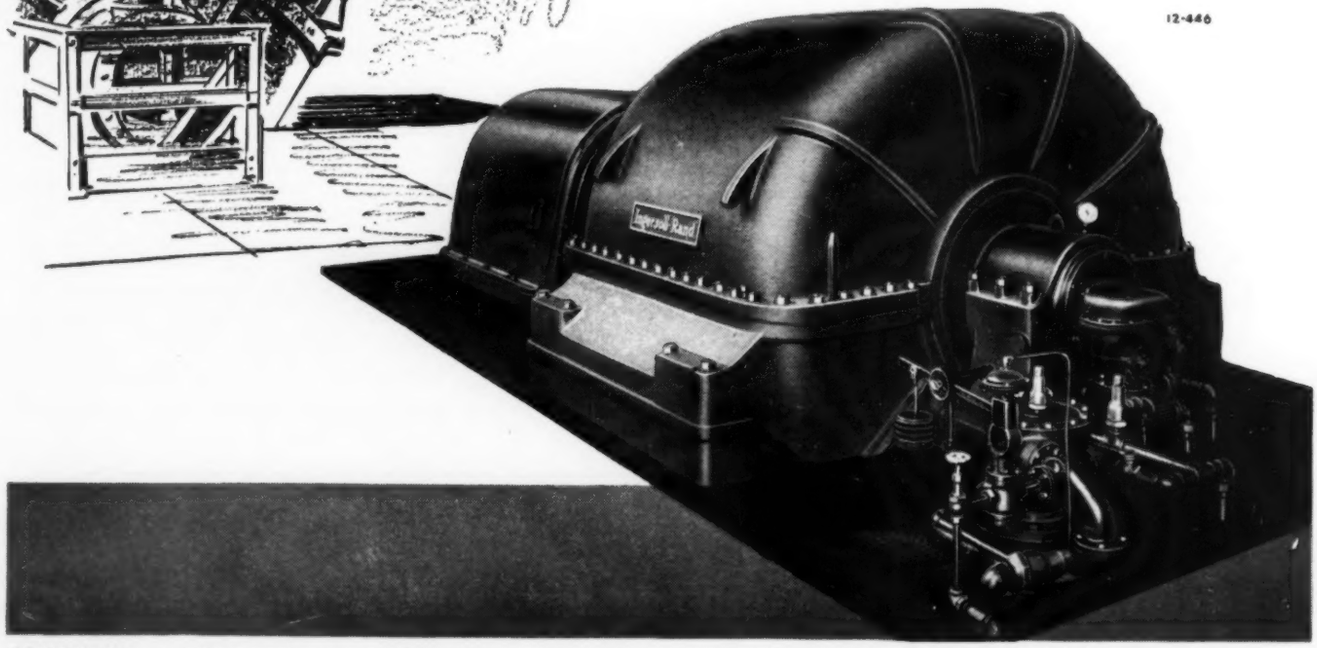
Turbo Blowers for converters, blast furnaces, heat treating and other metal processes have long been a specialty of Ingersoll-Rand. Many other industries also depend upon these blowers for the compression of air or gas. In the I-R line are units of from 2 to 15,000 horsepower. An experienced engineer will be glad to help with your blower problems.

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

This 4000 horsepower Turbo Blower delivers up to 30,000 cubic feet of air per minute to Bessemer Converters in a southern steel plant.

12-446



COMPRESSORS • TURBO BLOWERS • ROCK DRILLS • AIR TOOLS • OIL AND GAS ENGINES • CONDENSERS • CENTRIFUGAL PUMPS

On Cranes, Hoists, and Machinery
these EC&M Type WB Brakes
give HIGH-SPEED
PERFORMANCE
-REDUCED UP-KEEP

BY the addition of a compact rectifier-unit — available for separate mounting, as shown above, or combined with the motor control panel— you can now have as smooth, quick-acting and efficient brake performance on a-c motors as experienced for years on d-c motors.

These brakes not only eliminate the laminated members required in a-c brake design, but give quick response. High initial current insures *fast release;* automatic reduction of the holding current results in *fast setting.*

Many hundreds of these brakes are already in successful operation. Write today for new Bulletin 1006 on EC&M brakes for a-c operation.

Send for Bulletin 1006 for A-c;
Bulletin 1004-D for D-c.

OUTSTANDING FEATURES OF OPERATION

No laminated magnets or plungers.
No destructive hammer-blow.
No a-c chatter.
No coil burn-out due to shoe-wear affecting air-gap.
No motors, gears or pumps.
Has fast release and fast set.
Has ability to permit accurate inching.
Has hand release.
Has solid cast-steel magnet and armature.
Has short armature-movement.
Has thick, moulded brake blocks— 1/4" to 3/4" thick.

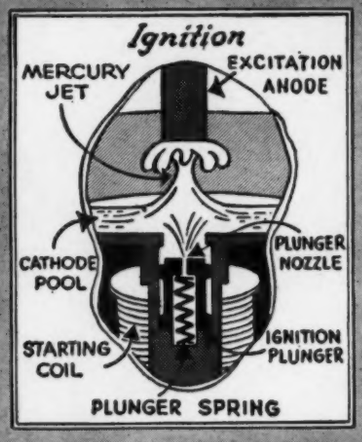
THE ELECTRIC
CONTROLLER & MFG. COMPANY
2698 EAST 79TH STREET CLEVELAND 4, OHIO

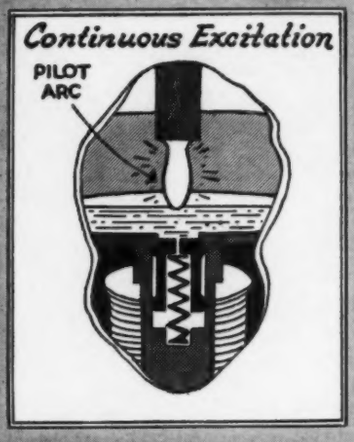
GET STABLE D-C

WITH EXCITRON MERCURY ARC RECTIFIERS!

Here's the Excitron Principle . . .

Allis-Chalmers Excitron employs simple, one-time ignition for "continuous excitation". To close circuit, plunger beneath mercury surface shoots jet up to excitation anode . . . which is safe distance above mercury cathode, *cannot be affected by impurities or turbulence on mercury surface.* When jet collapses, pilot arc remains.





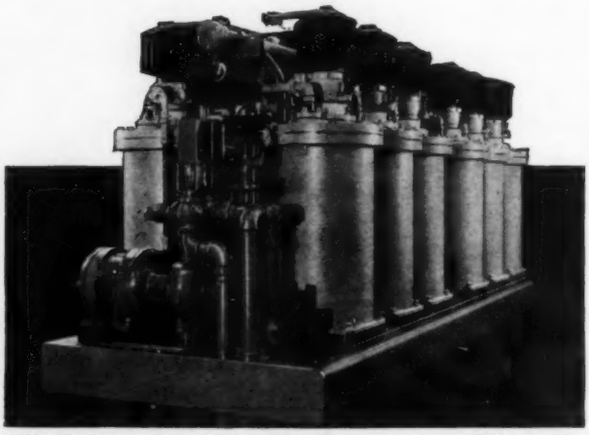
☛ **Allis-Chalmers' Excitron is the only single anode mercury arc rectifier which gives you the advantages of "continuous excitation".**

☛ **There are no ignition impulses to be synchronized with main anode voltage. Tubes don't require re-ignition at the start of each positive half-cycle.**

☛ **Only Excitron uses direct current from a 3-phase source for excitation of the tube. Thus, stability of excitation cannot be affected by average single-phase dips in a-c system voltage.**

☛ **Excitron has a simple excitation circuit which requires no "tuning" to maintain proper wave shape. Once adjusted at factory, no further adjustment needed.**

☛ **Write Allis-Chalmers, Milwaukee 1, Wisconsin, for the Excitron answer to all your power conversion problems.** A 1717



Allis-Chalmers engineers *introduced* mercury arc rectifiers to US.

ALLIS-CHALMERS EXCITRON MERCURY ARC RECTIFIERS

PHILCO

Again in the News

THE BATTERY THAT GIVES 30% LONGER LIFE

—Another Philco "First"

Revolutionary new

PHILCO "THIRTY"

WITH 30% LONGER LIFE RADICALLY CUTS MOTIVE POWER BATTERY COST!

★ ***Reduces depreciation and maintenance***
★ ***Gets more work done***
★ ***Packs a terrific wallop***

What every materials handling man wants in a storage battery is **packed** into this amazing new Philco "Thirty."

In high capacity, it is **tops** in the field—assuring the maximum tonnage every shift. Even after long hours of heavy work, it has the reserve power to climb ramps and grades, and complete the shift in *high*.

But the feature which sets the new Philco "Thirty" entirely apart from all other batteries you have known, used, or even heard of before—is its phenomenal long life. **30% longer life**—often more—has been demonstrated time after time in exhaustive field tests.

Here, then, is more than just a new and better battery. Here is a new standard of battery performance—*and* a new yardstick by which all battery values must now be judged.

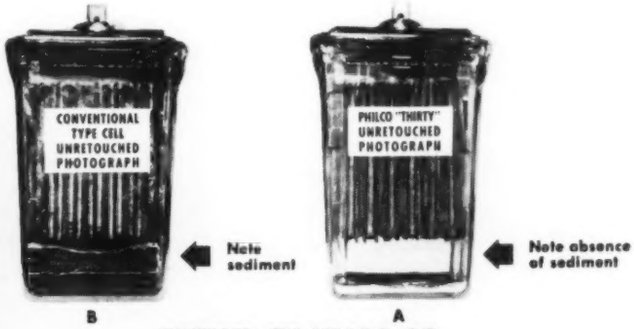
That's why it will pay you to get posted on this great new Philco Battery which is now available in certain types and limited quantities. Full information gladly will be sent on request.

REVOLUTIONARY NEW PRINCIPLE OF PHILCO FABRICATED INSULATION*

Only PHILCO "THIRTY" has it!

Here is a brand-new construction principle *and* an ultra-modern application of a proven insulating material. Both the results of Philco pioneering! This material is fabricated glass tape wrapped around the positive plates in two layers, first vertically and then horizontally. Even a single layer of this glass tape insulation has been found to have better retentive power in holding the active material in the plate, than the standard glass mat! And—of course, the plates of the Philco "Thirty" are further protected and insulated with the time tested Philco slotted rubber retainer and rubber separator. **Patent applied for*

YOU GET IT FIRST WITH **PHILCO**



PROVED BY YEARS OF FIELD AND LABORATORY TESTS

As proved in scores of service tests, these unretouched photographs show what happens when a Philco "Thirty" cell (A) and a conventional type cell (B) are tested side by side in motive power cycle service, charged and discharged in series in the same circuit. Glass jars were used here only to permit observation. Note almost total absence of sediment in the Philco "Thirty", while the sediment space of cell B is filled. Cell B has delivered its normal life expectancy and is worn out—while the Philco "Thirty" still delivers over 100% of rated capacity, with a long margin of serviceable life still to go.

THE CLIMAX OF 50 YEARS OF LEADERSHIP IN BATTERY RESEARCH AND ENGINEERING

The procession of Philco "Firsts", covering the whole field of motive power and stationary batteries, has set the pace in modern battery design. Check the developments, which have contributed most to today's higher capacities, increased efficiency, longer life, and lower cost—the record shows *you get it first with Philco.*

PHILCO VITRABLOC

A development for telephone, control and standby service, that materially increases battery room capacities.

PHILCO FLOTÉ

The battery that exerted a major influence on the wider use of full float service, by eliminating low cells. More efficient . . . more economical to maintain.

PHILCO HIGH CAPACITY CELLS

Through modern plate design, Philco showed the way to increased capacity without increase in over-all battery dimensions. A tremendous advantage in many motive power operations.

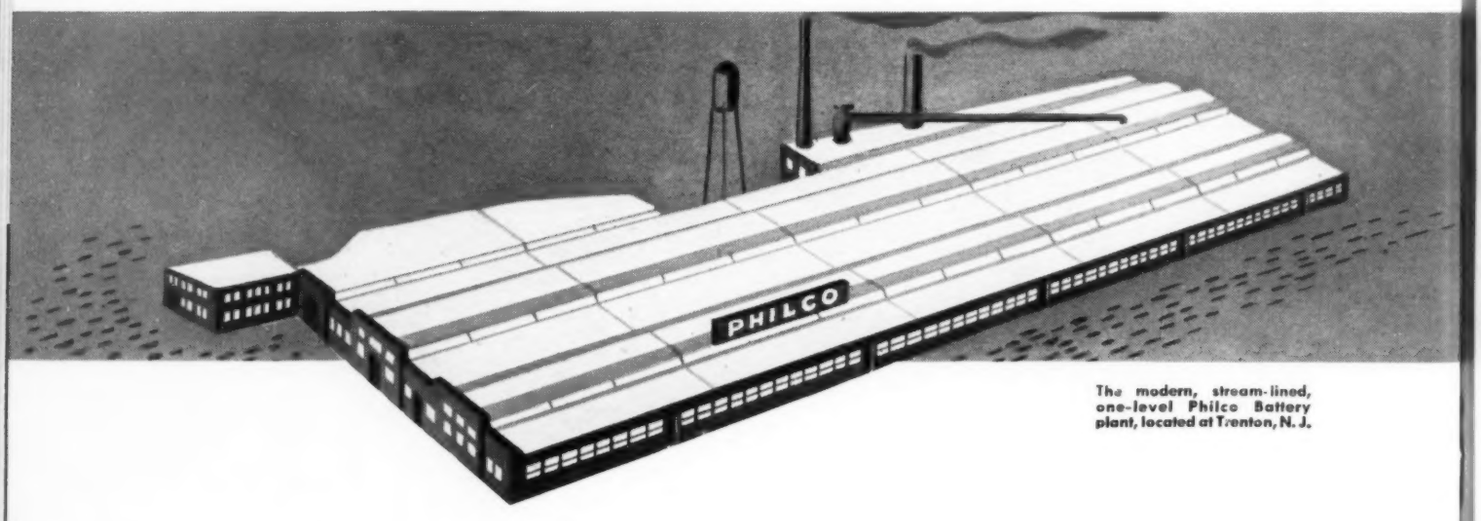
PHILCO

BUILT FOR MODERN DEMANDS BY THE LEADER IN MODERN BATTERY ENGINEERING

As described in the foregoing pages, Philco is ready, today, with the advanced battery performance and long-life economy you'll need in your post-war operations. With model manufacturing facilities, Philco is ready to produce these superior batteries in greater volume than ever before.

In the complete Philco line are modern storage batteries for all industrial applications—industrial trucks, mine locomotives and shuttle cars, diesel starting, railroad car lighting and air conditioning, control and power, telephone service and signal systems.

On your next purchase of batteries specify a modern Philco.

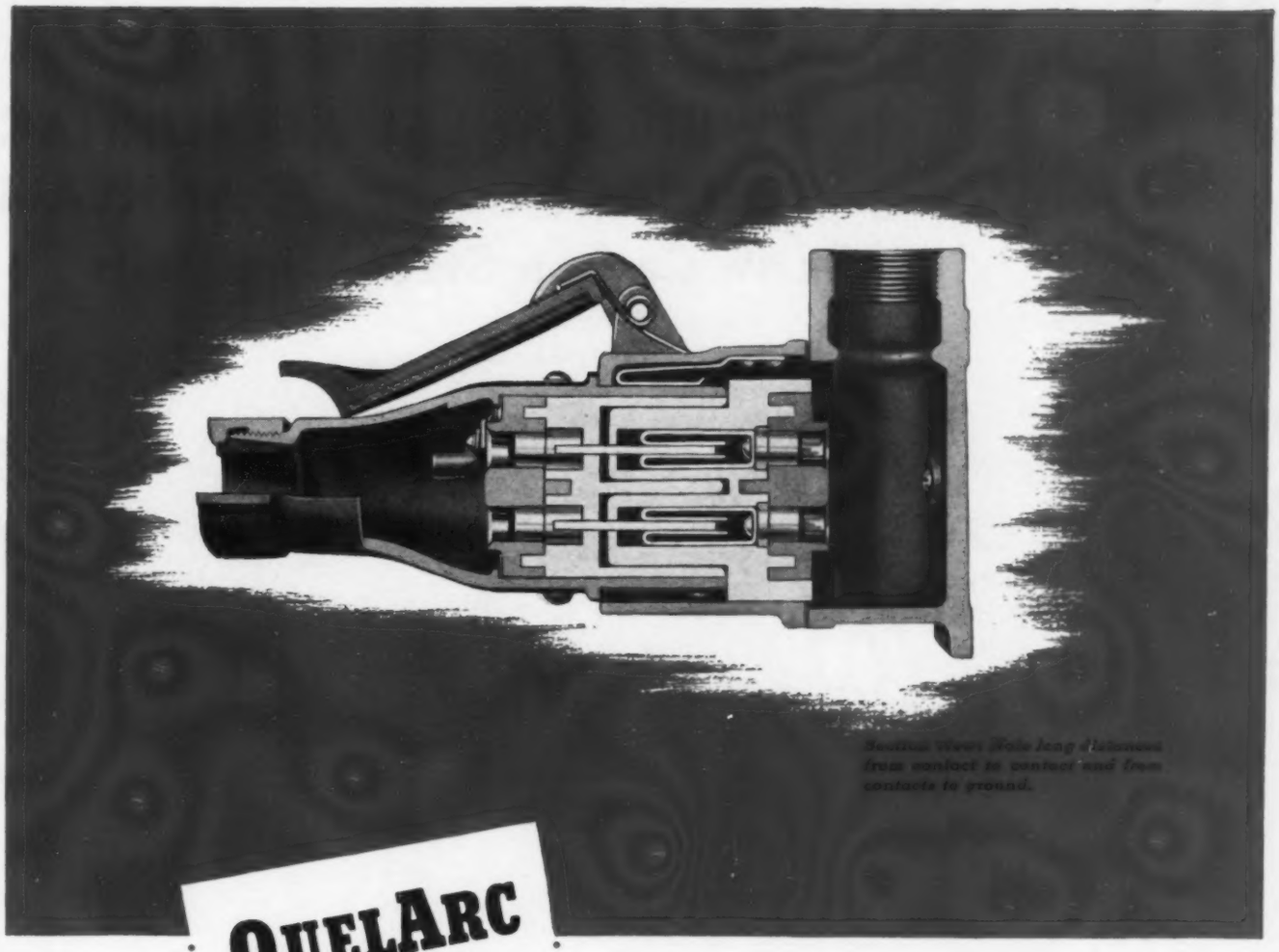


The modern, stream-lined, one-level Philco Battery plant, located at Trenton, N. J.

PHILCO CORPORATION

STORAGE BATTERY DIVISION • TRENTON 7, NEW JERSEY

For 50 Years a Leader in Industrial Storage Battery Development



QUELARC

The circuit breaking plugs and receptacles . . . ratings up to 200 amperes

Pyle-National plugs and receptacles are built to stand up in mill service, delivering dependable service with minimum maintenance. The exclusive QuelArc construction provides exceptional protection to contacts, for safe use as current rupturing devices. In the section view, note the complete enclosure of all contacts in insulating chambers which form an arc-trapping space. Note also the long distances from contact to contact and from contacts to ground. Contacts are individually renewable. Full ground protection is provided.

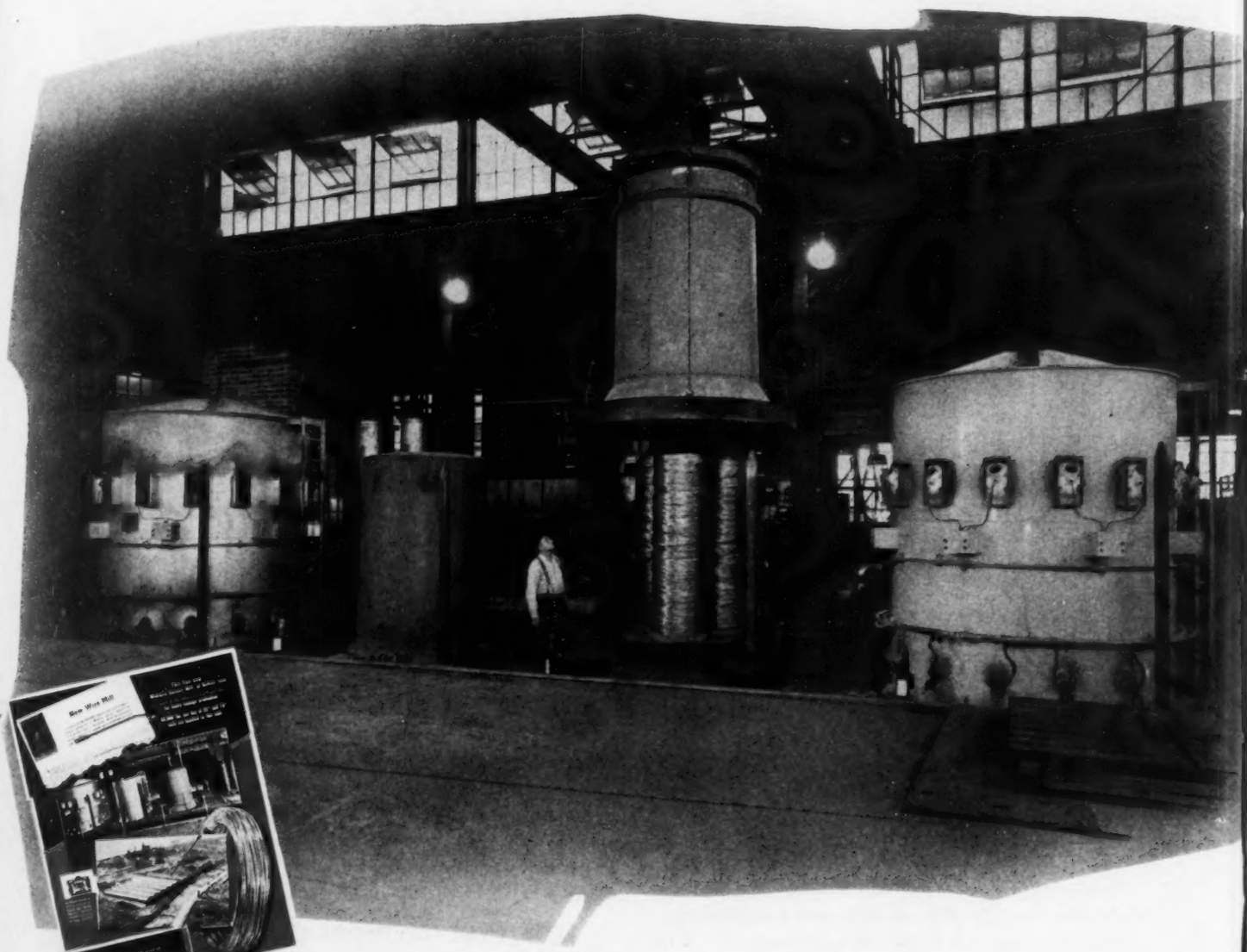
QuelArc plugs and receptacles are available in a complete range of styles, 2, 3, 4 wire types; ratings 20, 30, 60, 100, and 200 amperes. Many other types available for portable tools and control and instrument circuits. Write for general catalog 1100 with listings of all types.

THE PYLE-NATIONAL COMPANY
1334-58 North Kostner Avenue • Chicago 51, Illinois
Offices: New York, Baltimore, Pittsburgh, St. Louis, St. Paul, San Francisco

PYLE-NATIONAL
ELECTRICAL EQUIPMENT
• SINCE 1897 •

CONDUIT FITTINGS • FLOODLIGHT PROJECTORS • LOCOMOTIVE ELECTRICAL EQUIPMENT

WILSON WIRE ANNEALING FURNACE
for HEAVY TONNAGE PROCESS ANNEALIN
of Low Carbon Steel Wire Coils



The first installation at Wickwire Spencer - 1940

This Wilson installation at Wickwire Spencer Company's Buffalo plant utilizes two 62" x 84" furnaces on four bases for heavy daily process annealing tonnages of 22" and 16" block coils. Larger base sizes with fan recirculation are available for larger and exceptionally heavy coils.

The Wilson Annealing Unit is covered by Patents Nos. 1,952,402, 2,068,477, 2,078,356, 2,081,812, 2,089,843 and other patents pending

ENGINEERED AND CONSTRUCTED B

Lee Wilson ENGINEERING Co., In

20005 West Lake Road CLEVELAND, OHIO

Telephone ACademy 4670

INDUSTRIAL FURNACES · RADIANT TUBE HEATING · HEAT TREATING PROCESS

TIMKEN BEARING EQUIPPED

ROD MILLS
show exceptional speed and precision

The above photograph shows one of three 19-stand rod mills operating in the plant of a large wire manufacturer. All of the mills are equipped with Timken Roll Neck Bearings and have been in service up to 7 years.

These rod mills are particularly notable for the high speeds at which they operate and for the extremely close rolling tolerances consistently maintained.

The product rolled is primarily No. 5 rod, on which the accepted commercial tolerance for hot roll machine straightening is plus or minus .005", but the operators of these Timken Bearing Equipped mills are easily able to hold their tolerances to plus or minus .003".

Outstanding performance in rolling mills of all kinds — rod mills, strip mills, plate mills and slabbing mills — is the rule when Timken Bearings are used on mill roll necks; screwdowns; approach and run-out tables. You will need them to successfully meet the competitive demands of peace. Make sure you have them. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
ROLL NECK BEARINGS

UNITED

HEAVY DUTY ROLL LATHES

Headstock Faceplate Directly Driven by "CONE WORM" Gears

Advantages

1. Operation at a Steady, Uniform Speed—"CHATTERLESS"
2. Cone Worm Drive Permits Compact Construction
3. Low Head Room—Facilitates Entry of Roll
4. Motors Protected by Headstock
5. Cone Worm Drive Rated Conservatively

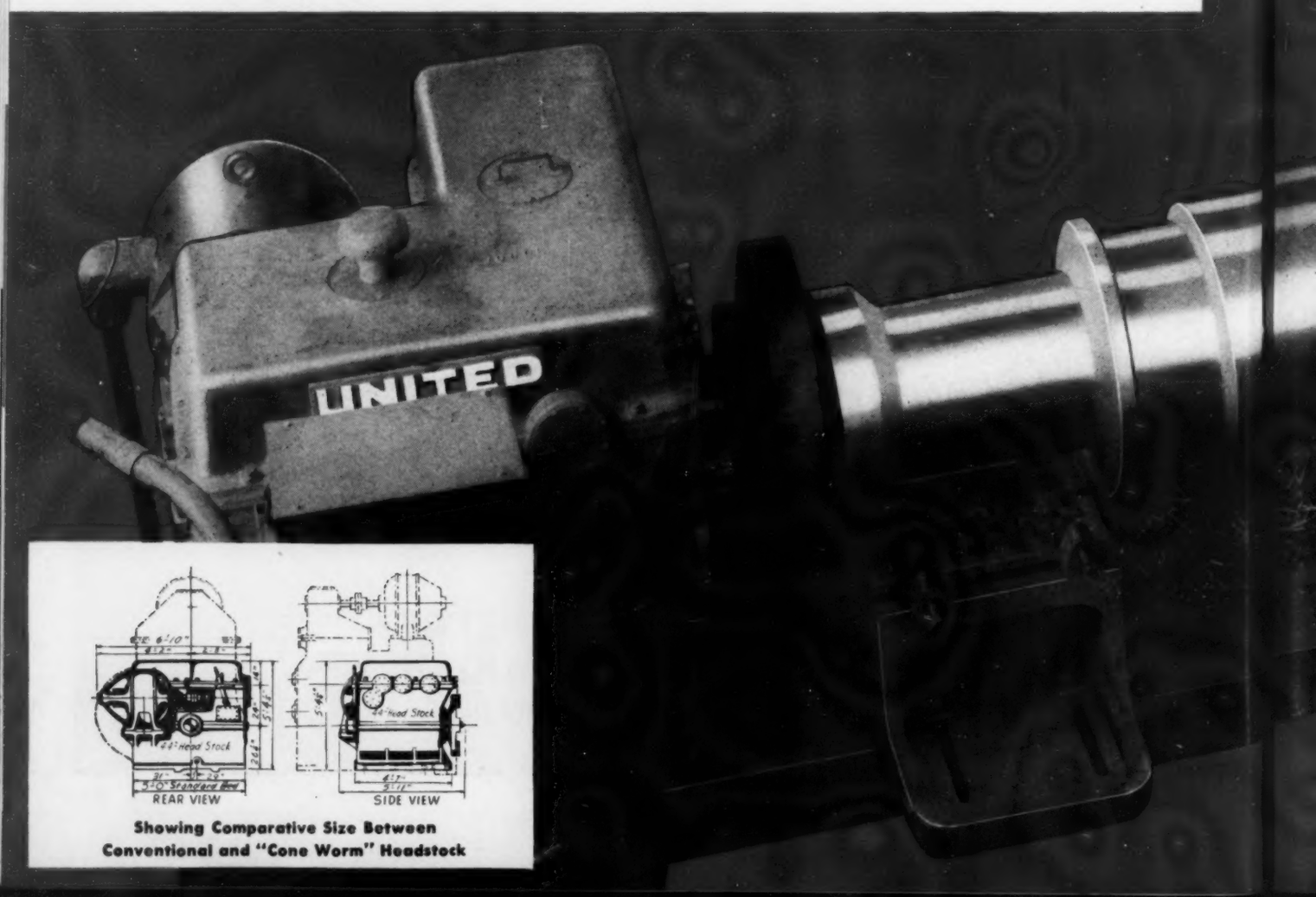
The "Cone" type of worm gearing used in UNITED-HEAVY-DUTY ROLL LATHES, with its hour-glass shape of worm partially "wrapping" the gear and thus bringing more teeth in constant contact, provides maximum capacity in the smallest space, and chatterless operation. This superiority has been definitely established by test and experience in UNITED 4-high mill screwdown applications.

Low head room facilitates crane handling of rolls, and compact construction permits more floor space and visibility between lathes.

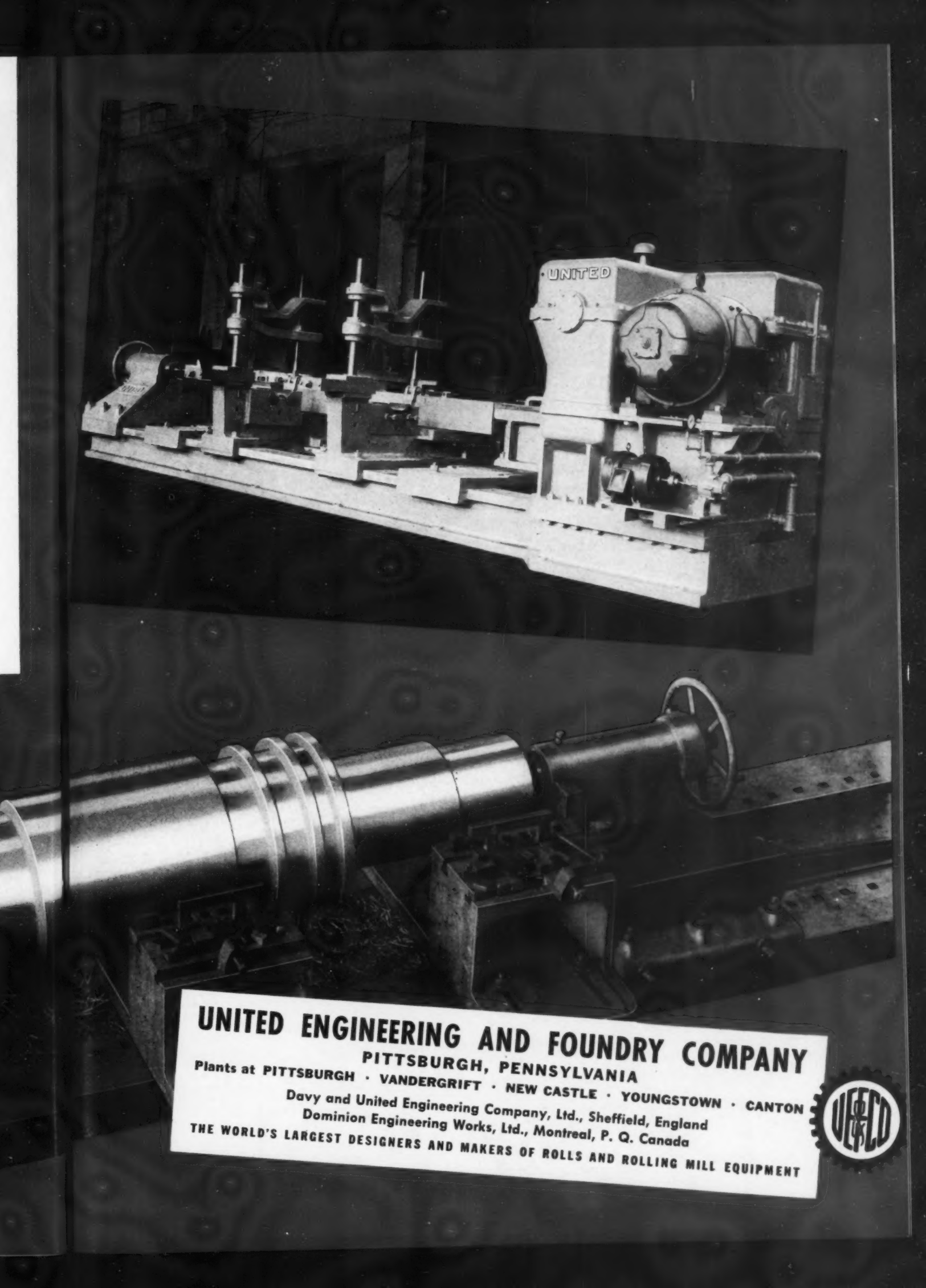
All gearing up to the main cone worm faceplate drive is either single or double helical, is fully roller bearing mounted and carefully proportioned with reference to both velocity and load requirements. These fully enclosed gears and bearings are lubricated by forced oil circulation.

UNITED HEAVY-DUTY ROLL LATHES can be furnished for either "fixed" or "rotating" center.

Consult UNITED engineers for complete technical data.



Showing Comparative Size Between Conventional and "Cone Worm" Headstock



UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

Plants at PITTSBURGH · VANDERGRIFT · NEW CASTLE · YOUNGSTOWN · CANTON

Davy and United Engineering Company, Ltd., Sheffield, England

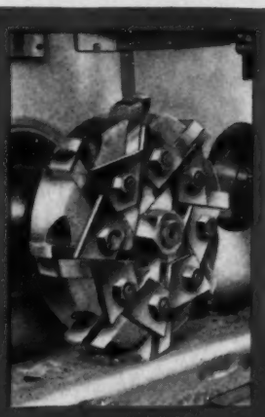
Dominion Engineering Works, Ltd., Montreal, P. Q. Canada

THE WORLD'S LARGEST DESIGNERS AND MAKERS OF ROLLS AND ROLLING MILL EQUIPMENT

U.E.&F.CO.

Billeteers

• MECHANIZE • YOUR BILLET • CONDITIONING •

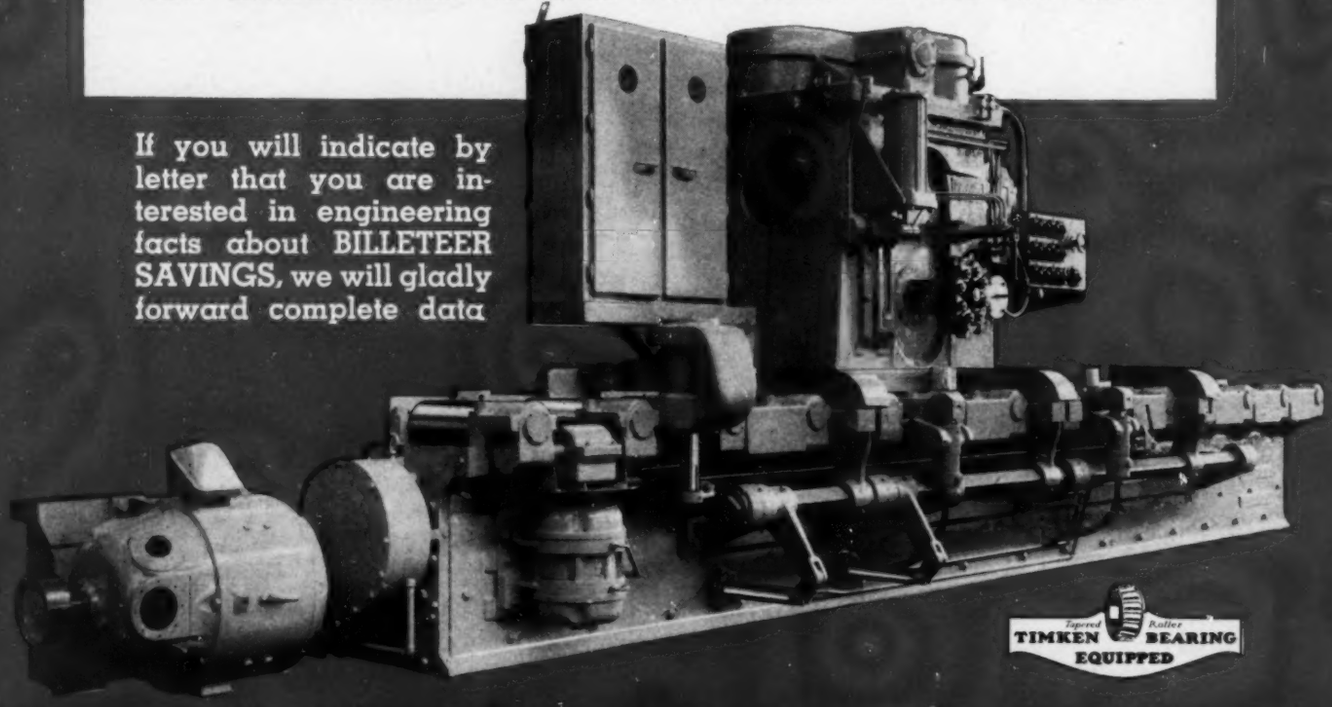


clean faster, better and at less cost than by any other method

- LOWER BILLET CLEANING COSTS—All users report savings. One averages $2.50 per ton.
- LOWER FIRST COST—Compared with returns on other equipment.
- LOWER UPKEEP COSTS—Compared with tools, repairs and supplies for 20 manual chippers.
- LOWER ENERGY CONSUMPTION—Savings better than 60 per cent.
- LOWER "HEAT" LOSSES—Whole heats that go bad can be salvaged.
- LOWER LABOR TURNOVER—One OPERATOR vs. 20 fast changing laborers.
- LOWER OVERHEAD COSTS—Compare costs in personnel records, space, accommodations and headaches

THESE SAVINGS ARE A BOON TO THE ENGINEERING AND PRODUCTION STAFFS — THEIR RECOMMENDATIONS WILL MAKE THEM A REALITY ON YOUR COST SHEETS.

If you will indicate by letter that you are interested in engineering facts about BILLETEER SAVINGS, we will gladly forward complete data

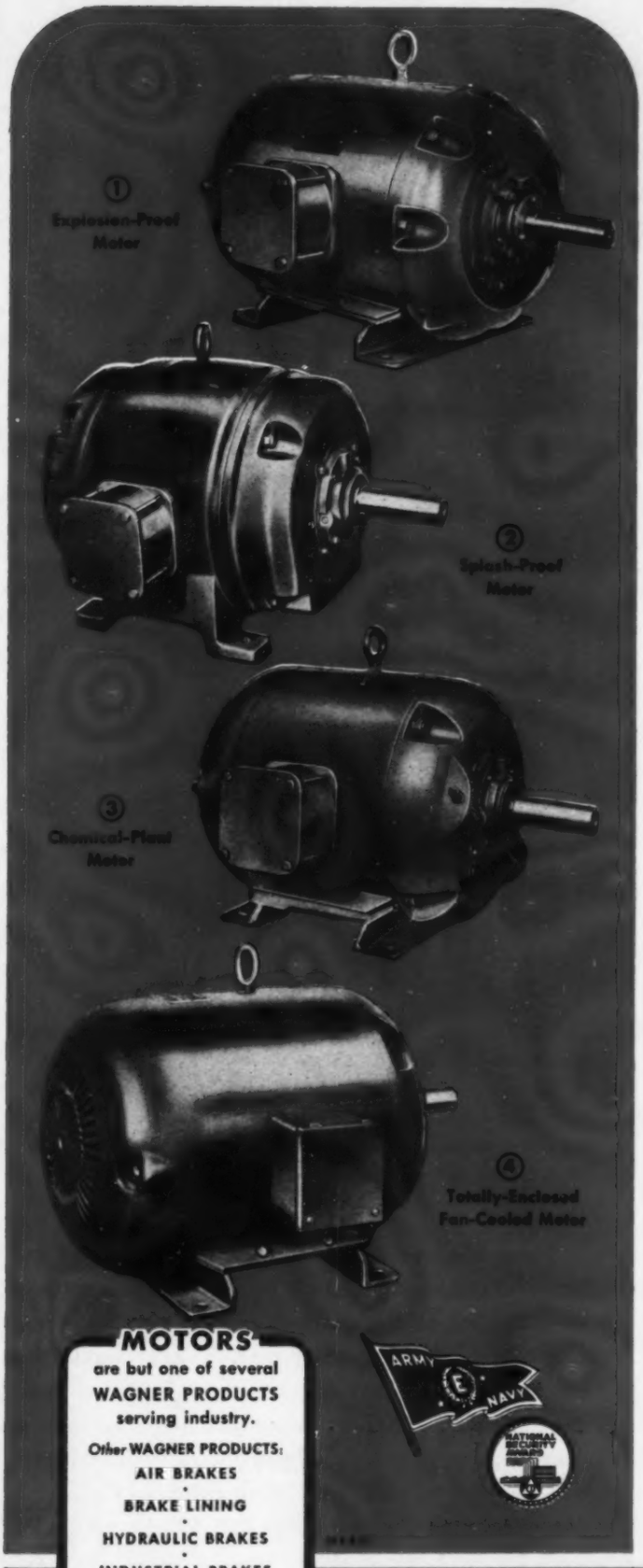


STEEL EQUIPMENT DIVISION OF **THE BONNOT COMPANY, CANTON, OHIO**

BONNOT

ENGINEERED FOR IMPROVED PRODUCTION

WRITE US FOR COMPLETE FACTS



Use a

Wagner

PROTECTED MOTOR

for that "TOUGH" job

1 WAGNER EXPLOSION-PROOF MOTORS have been approved by the Underwriters' Laboratories for Class 1 Group D hazardous locations, "where gasoline, petroleum, naphtha, alcohols, acetone, lacquer solvent vapors, or natural gas are manufactured, used, or handled".

2 WAGNER SPLASH-PROOF MOTORS are built to operate dependably in locations where they are subject to splashing water, oil, or other liquids. They are widely used in unprotected outdoor locations, being designed with complete self-protection against rain, snow, ice, and sleet.

3 WAGNER CHEMICAL-PLANT MOTORS are designed to resist the action of acids, fumes, moisture, and other harmful elements encountered in chemical manufacturing plants. The moisture-proof and dust-tight conduit box prevents dust, fumes, or moisture from entering the motor. Special drainplugs are provided which permit the removal of condensate from the motor or conduit box.

4 WAGNER TOTALLY-ENCLOSED FAN-COOLED MOTORS are designed to operate under severe and adverse conditions in atmospheres that contain dust, dirt, abrasives, steel chips, filings, acid fumes, and other ordinarily harmful elements. The two-frame construction permits the complete sealing of windings and bearings, and the admission of a cooling draft over the motor.

MOTORS are but one of several **WAGNER PRODUCTS** serving industry.

Other WAGNER PRODUCTS:

AIR BRAKES
•
BRAKE LINING
•
HYDRAULIC BRAKES
•
INDUSTRIAL BRAKES
•
INDUSTRIAL BRAKE CONTROLS
•
TACHOGRAPH (Recording Speedometer)
•
TRANSFORMERS

ARMY E NAVY

NATIONAL SECURITY AWARD

Write for **BULLETINS**

Everyone who is responsible for the purchase, installation, or maintenance of electric motors should have Bulletins MU-182 (Polyphase Motors) and MU-183 (Single-phase Motors).

Besides these two bulletins your files should hold Service Bulletins MU-7, MU-26, and MU-30, and also Wagner's general Bulletin GU-82 on "Wagner Products for Industry".

Wagner Electric Corporation

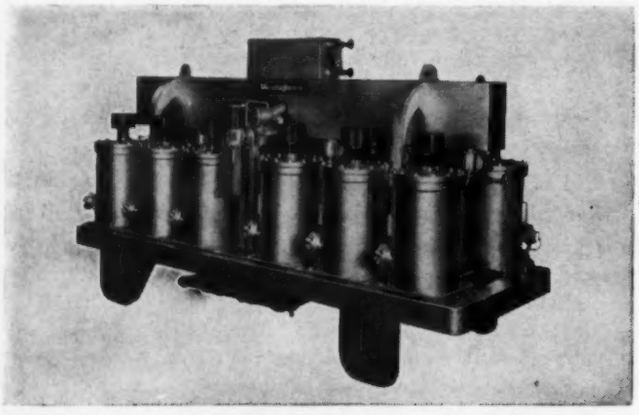
ESTABLISHED 1891

6483 Plymouth Avenue, St. Louis 14, Mo., U. S. A.

ELECTRICAL AND AUTOMOTIVE PRODUCTS

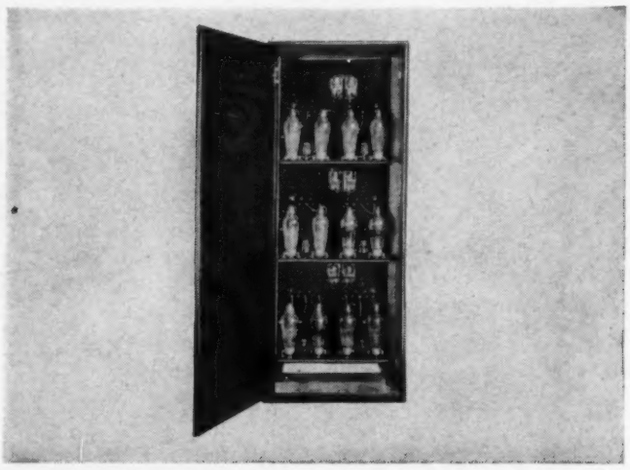
3 WAYS ELECTRONICS CAN BOOST YOUR STEEL PRODUCTION

MOT-O-TROL—provides an efficient means for precision control of auxiliary motors. A single, handy control station governs all functions—starting; smooth, rapid acceleration to a pre-set speed; speed changes; and the application of dynamic braking for quick stops and reverses.



IGNITRON RECTIFIER—is a revolutionary Westinghouse development for more efficient power conversion. Its high short-time overload capacity makes it particularly suited for steel mill applications. Sustained operation at high efficiency, for light or heavy loads, is a characteristic of its construction.

Want greater production efficiency? Here's a tip—for greater power, for precision control, use *electronics*. Westinghouse is ready with timesaving, moneysaving electronic devices, specifically designed for steel mill applications. Here are three examples—Westinghouse developments already proved in use:



ELECTRONIC ARC FURNACE REGULATOR—is one of the latest Westinghouse electronic developments. It has no moving or vibrating parts, and uses standard electronic units. Since tubes provide the dual function of control and rectification, it eliminates the necessity for providing d-c for the electrode motors. It assures exceptionally smooth operation.

★ ★ ★

These electronic tools are representative of the many electrical solutions Westinghouse has successfully applied to the complex problems of steel mill production. Each development—each application represents specialized engineering co-operation with the individual customer. When you need this type of assistance, your nearest Westinghouse representative will be glad to serve you. Westinghouse Electric & Manufacturing Company, Box 868, Pittsburgh 30, Pa.

J-94648

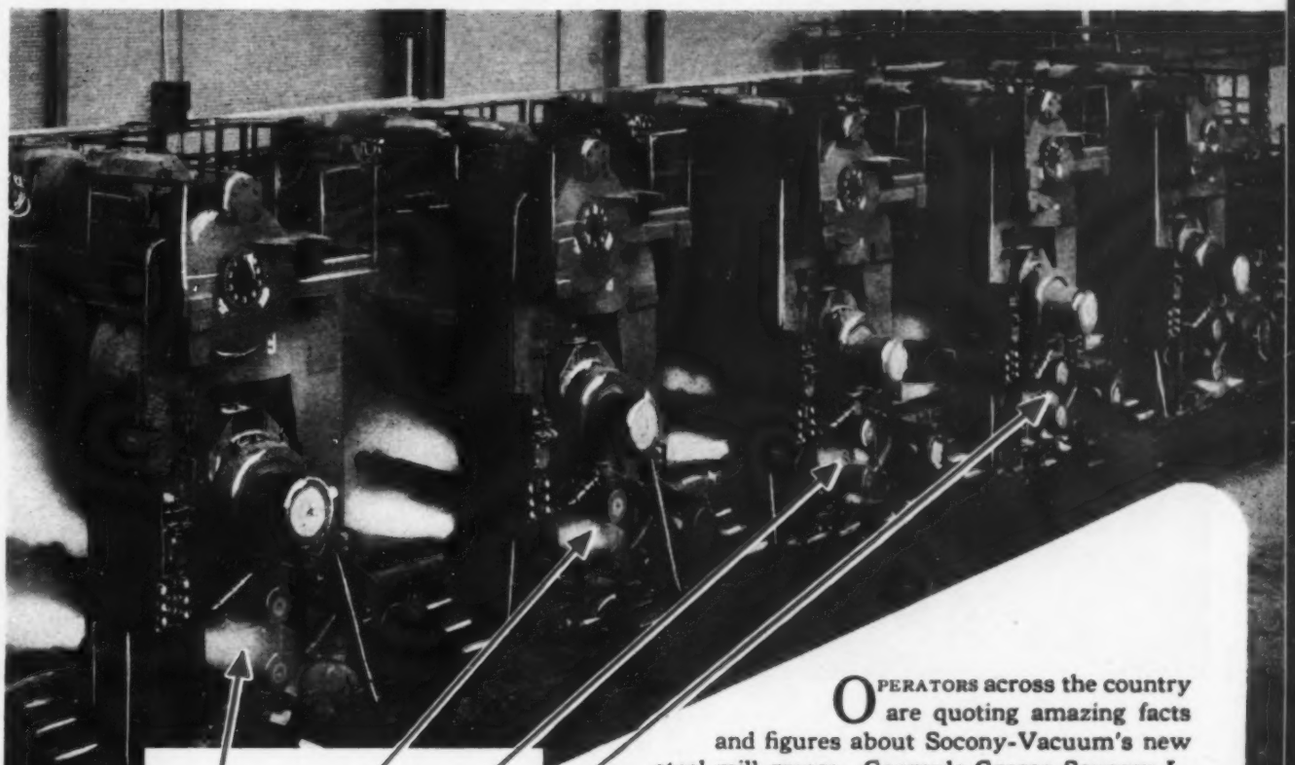
Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Electrical partner of the Steel Industry

HOW TO SOLVE OPERATING PROBLEMS WITH *Correct Lubrication*

Get Full Details about this New Patented Grease!



GARGOYLE GREASES SOVAREX L RESIST

- Softening under heat.
- Water and corrosion.
- Separation.
- Wear under loads.

OPERATORS across the country are quoting amazing facts and figures about Socony-Vacuum's new steel mill grease—Gargoyle Grease Sovarex L. Many report bearings operating perfectly a great deal longer between grease applications. Others report remarkably little softening under increased temperatures—up to as high as 450°F. All report surprising resistance to heavy pressures and the washing effect of water and greatly reduced wear and leakage.

You can get full details on these experiences of other operators from your Socony-Vacuum representative. Be sure to ask him for them.

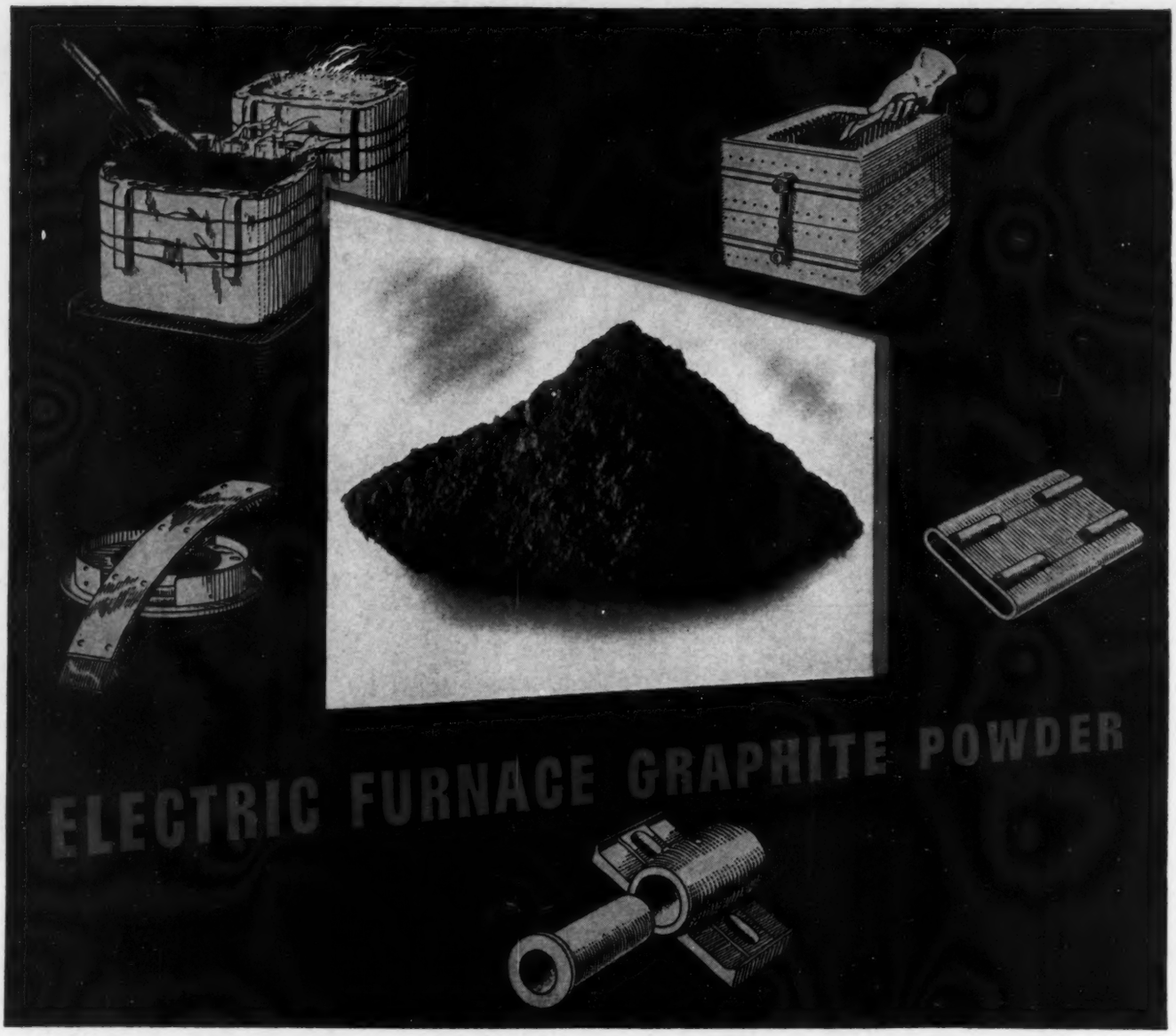
SOCONY-VACUUM OIL COMPANY, INC.—Standard Oil of N. Y. Div. • White Star Div. • Lubrite Div. • Chicago Div. White Eagle Div. • Wadhams Div. • Magnolia Petroleum Company • General Petroleum Corporation of California.

GARGOYLE Lubricants

Call in Socony-Vacuum for New Patented

GARGOYLE GREASE SOVAREX L

ONE OF A SERIES OF SUGGESTIONS TO AID PRODUCTION



MAKES THEM BETTER!

As a HOT-TOPPING COMPOUND, it produces sounder ingots by reducing the size of the pipe. As a mold wash, it prevents stickers. It provides brake linings with essential qualities for longer life. It is the lubricant of many oilless bearings. It is formed into electronic tube elements of high efficiency.

These are a few of the many jobs that "National" electric furnace graphite powder performs . . . to make things better!

To this end, an increasing amount of graphite powder goes each year to the iron and steel, foundry, chemical and process, petroleum, rubber, mechanical, and many other industries. Besides the applications illustrated, graphite powder is used in powder metallurgy, clutch facings, fabric belting, greases, wire drawing, rubber compounds, powder glazing, crucibles, batteries, boilers, ink and paint pigments, pencils, crayons. The list grows steadily.

"National" electric furnace graphite powder comes in a number of grades, each classified on the basis of purity, electrical resistance, and fineness . . . all held within accurately controlled limits.

Ask us how electric furnace graphite powder may help serve you . . . or serve you further.

KEEP YOUR EYE ON THE INFANTRY
. . . THE DOUGHBOY DOES IT!

The word "National" is a registered trade-mark of National Carbon Company, Inc.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

General Offices: 30 East 42nd Street, New York 17, N. Y.
Division Sales Offices: Atlanta • Chicago • Dallas • Kansas City • New York • Pittsburgh • San Francisco

At THOMAS' they look to the GEAR WITH A BACKBONE

Farrel-Sykes continuous tooth herringbone gears are used in the giant shears built by Thomas Machine Manufacturing Company because they have proved their ability to withstand the continual shocks and stresses to which they are subject in this heavy duty service.

Because the two helices meet to form continuous teeth, the entire face width is put to work, and the *backbone,* which takes the place of the center groove in some gears, provides extra strength and high load-carrying capacity.

In addition, precision generation by the Farrel-Sykes process, overlap or interlacing of the teeth, gradual engagement and inclined line of pressure contribute to smooth operation and maintenance of correct tooth action throughout the life of the gears. The opposed helices balance and absorb axial thrust within the gear member, preventing harmful thrust loads with resultant stresses on other parts of the machinery.

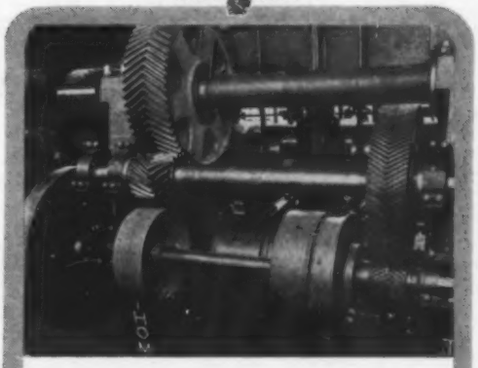
For the complete story of the *Gear with a Backbone,* send for a copy of Catalog No. 438. Or, if you prefer, one of our engineers will be glad to discuss your gear problems with you at any time.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN., BUFFALO, N. Y.

Plants: Ansonia and Derby, Conn., Buffalo, N. Y.

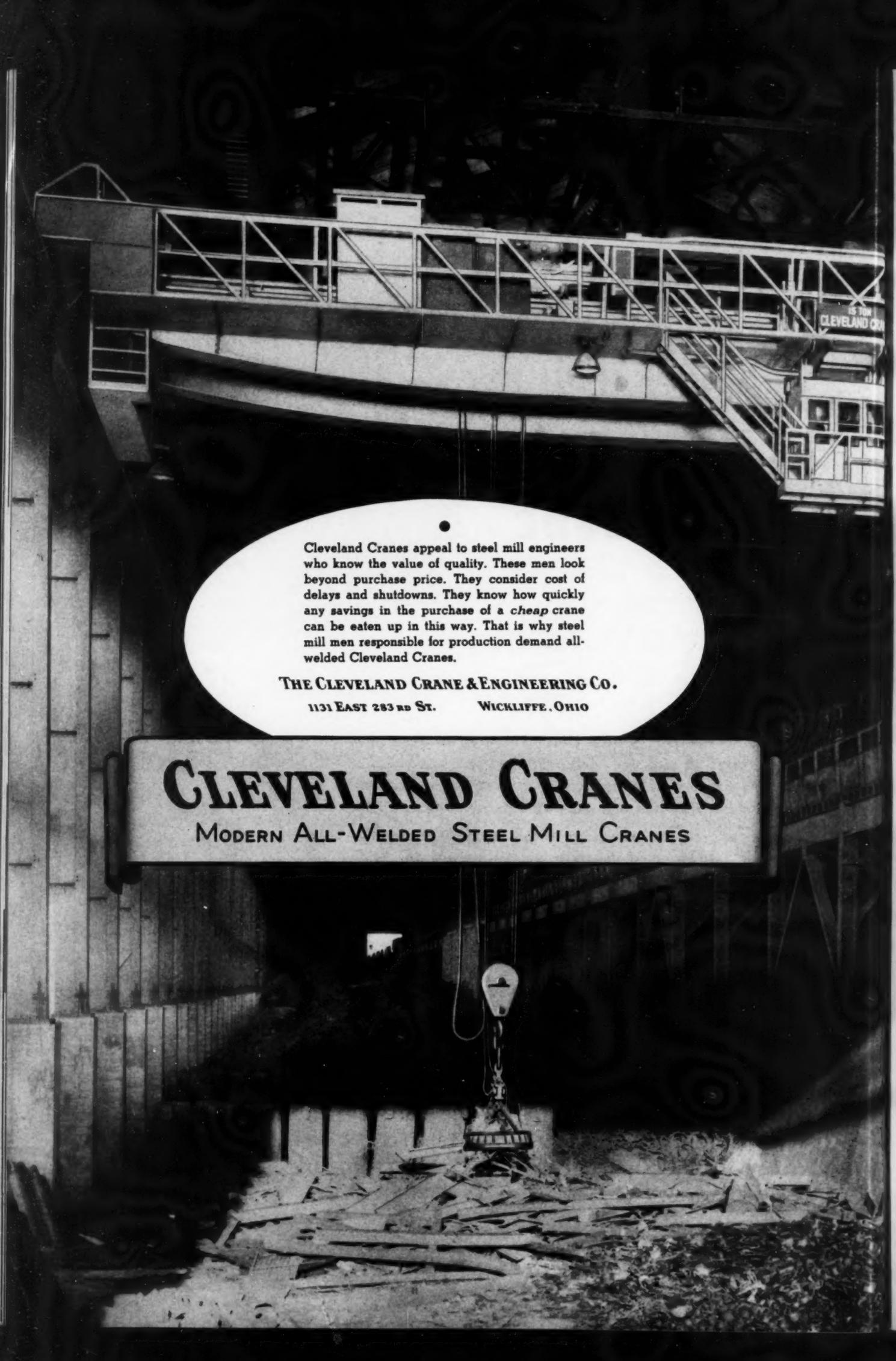
Sales Offices: Ansonia, Buffalo, New York, Pittsburgh, Akron, Los Angeles, Tulsa, Houston

FARREL



This rear view of the Thomas Shear shows two pairs of Farrel-Sykes continuous tooth herringbone gears in the drive. The main gears are shown in the front view above; they are 120″ diameter, 20″ face. This massive shear will cut mild steel 3″ thick x 120″ wide.

Farrel-Birmingham



Cleveland Cranes appeal to steel mill engineers who know the value of quality. These men look beyond purchase price. They consider cost of delays and shutdowns. They know how quickly any savings in the purchase of a *cheap* crane can be eaten up in this way. That is why steel mill men responsible for production demand all-welded Cleveland Cranes.

THE CLEVELAND CRANE & ENGINEERING CO.

1131 EAST 283 RD ST. WICKLIFFE, OHIO

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

Crops and Shorts

BLAST furnaces and electric furnaces go begging at present in contrast to the scarcity two years ago. The American Iron and Steel Institute states that 16 blast furnaces (one a new unit never operated) are idle because of lack of outlet for iron, while 14 more are inactive because of repairs or other reasons. October pig iron production was 5,200,175 tons, up slightly from the September low of 4,987,645 tons. The drop in alloy steel production from 11,432,939 tons in the first 10 months of 1943 to 8,874,012 tons in the first 10 months of this year accounts for the idleness of many electric furnaces.

▲

THE Iron and Steel Institute also gives the figure $528,000,000 expended for steel plant repairs and maintenance during 1943. This is the highest figure on record for this item. Previous years have run about as follows:

1942	$465,000,000
1941	$420,000,000
1940	$305,000,000
1939	$247,000,000
1938	$171,000,000

▲

WE see by the paper that WPB has allotted the transportation industry greater quantities of metals for rolling stock. Judging from recent train rides we didn't know the darn things still rolled.

▲

GENERAL indications, however, point to less steel for civilian use, with cancellations of early conversion plans and a sidetracking of civilian production. Demands for steel for small and medium sizes of ammunition are definitely up, and the requirements for large sizes will also increase. Combat experience has revised original estimates, and it is said that we are using ten rounds of ammunition to the German's one, with a marked saving in casualties.

▲

AMERICANS on the home front seem to be poor "front runners." Three years ago, when we were taking a pretty good shellacking, we buckled down and produced, bought bonds, donated blood, etc. Now that we are in the win column, we're slacking off — war workers are leaving their jobs, bond sales are off, blood banks are lagging. General Somervell states that, for the first time since Pearl Harbor, it is necessary to increase war output in order to keep up with front line consumption. It is no longer a job of building up our reserves of munitions.

▲

ADJACENT stories in the Pittsburgh Press recently: "CIO Convention Renews Pledge Not to Strike — Murray Calls Promise Sacred Obligation."

"5000 Made Idle by Steel Strike — Bomb, Shell Casing Production Halted."

▲

UNDER the headings of increased vacation pay, differentials in night shift rates, etc., steelworkers have been granted a raise estimated at 7 cents an hour, bringing the average rate for the industry up to $1.25 per hour. The increase will add about $75,000,000 per year to the cost of production, or about $1.15 per ton of finished steel.

▲

NEW projects, both foreign and domestic, continue to flood the manufacturers and contracting companies. As one builder put it, the construction department is working at 50 per cent capacity, and the estimating department at 300 per cent. It is felt that a considerable volume of new projects will be held up until a day's work can be obtained for a day's pay.

▲

AT the crest of German power, an annual steel capacity of close to 60,000,000 tons was available in Axis Europe. This has been reduced to perhaps 36,000,000 tons by Allied advances and it is further estimated that as much as 20 per cent of this remaining capacity has been lost through bombing and sabotage.

▲

A NEW committee, composed of the doctors heading the medical departments of steel companies, has been formed by the American Iron and Steel Institute. Called the committee on industrial health, this group will study programs set up by the various companies for rehabilitating war veteran employees needing special consideration.

▲

IN the three years since Pearl Harbor, steel plants of the United States have produced more than 263,000,000 tons of steel ingots and castings.

▲

IN Greece a newspaper costs two billion drachmas and a gold pound is worth 32 trillion drachmas. In France cigarettes are worth more than francs. In China businessmen need coolies and bushel baskets to take their daily cash deposits to the bank.

▲

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Iron and Steel ENGINEER

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MODERN TRENDS IN

Blast Furnace Design

. . . . since World War I, the number of blast furnaces in the United States has steadily decreased while their size steadily increased . . . . performance of the large modern units would indicate that even larger furnaces can be operated successfully . . . .

by FRANK JANECEK

BLAST FURNACE ENGINEER

REPUBLIC STEEL CORPORATION

CLEVELAND, OHIO

▲ TRENDS in blast furnace design have been discussed from many angles in recent years, but a historical review extending over the past twenty-five years shows a number of interesting items that should not be overlooked. This is especially true since a startling decrease in the number of blast furnaces has been accompanied by a substantial increase in capacity.

In Figure 1 is plotted the number of blast furnaces in existence each year, starting with 1916. In that year there were 421 furnaces and the number increased to 437 by 1918. From that year the curve starts downward as the period from 1918 to 1925 brought considerable dismantling, with 38 furnaces falling by the wayside. This represents a loss of 5.4 furnaces per year.

From 1925 to 1930 an even more rapid rate of abandonment occurred, with a further loss of 86 units for an average of 17 furnaces each year — a remarkable period. However, in defense of this, it can be said that the abandoned furnaces were small, isolated furnaces with no hope of future economic operation, and were dismantled for their scrap value.

The next period (1930-1935) shows an additional loss of 39 units. This is an average of 7.8 furnaces each year, and in the next five-year period (1935-1940) the downward trend assumed a faster rate as 41 more furnaces were abandoned.

Thus, 25 years after 1915 we had 232 blast furnaces left standing which might have been operated. Many of the furnaces which were dismantled could not be supplied economically with raw materials and they could continue to operate only so long as ore, coal and coke could be produced cheaply. Whenever any of these materials decreased in quality or greatly increased in cost, the blast furnaces had to be abandoned.

The trend toward fewer units has been accompanied by a marked trend toward larger units, reflected in Figure 2 which shows the trend line for annual capacity increasing from about 43 million tons in 1916 to 58 million tons in 1941. Thus, with a reduction of almost 45 per cent in the number of operating units, we experienced an actual increase of 35 per cent in total capacity.

Figure 3 has been compiled to show the average capacity per furnace each year over this 25 year period. It shows that in 1916 we produced approximately 135,000 tons from each unit operating, while in 1941 we produced 270,000 tons, thus doubling the average individual furnace capacity in 25 years.

This is more clearly shown in Figure 4, which shows the average daily production of operating furnaces in 1916 at slightly under 380 tons per day. This figure increased at a fairly steady rate until the year 1930 when the average tonnage was 670 tons. This means there was a 77 per cent increase in approximately 15 years. After 1930 the curve shows a falling off to a low of 530 tons per day which was brought about by the depression, when furnaces were purposely operated at curtailed rates. However, the capacity trend really continued upward, and in 1942 we find 795 tons as the average production from each unit. While the period

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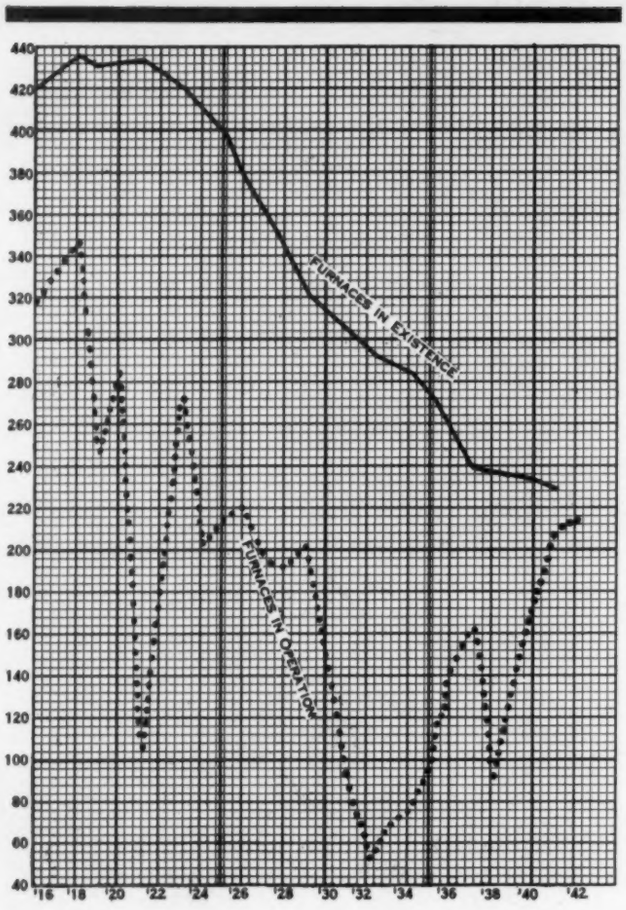
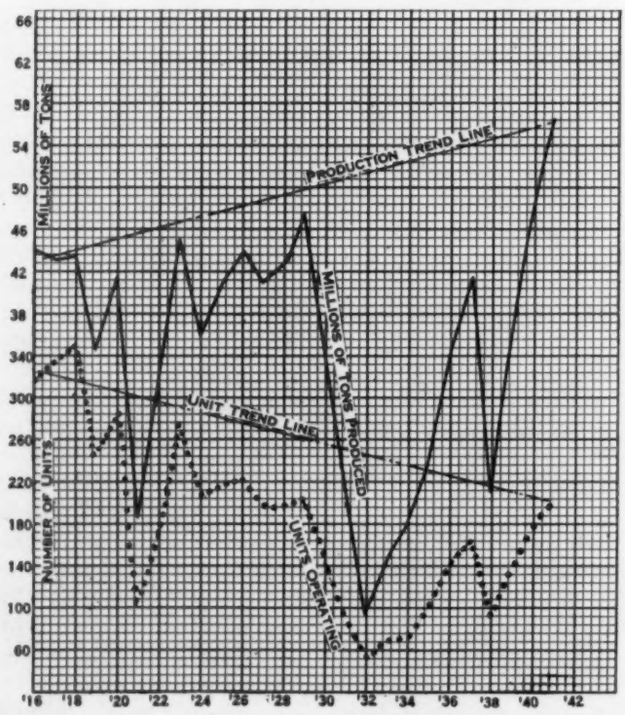


Figure 1 — Chart showing the number of blast furnaces in existence and the number in operation, year by year.

▲

Figure 2 — Yearly record of pig iron production compared with the number of blast furnaces operating.



from 1930 to 1942 shows a production increase of only 19 per cent per furnace, the trend curve clearly shows that the capacity of furnaces was doubled in the past 25 years.

Table I shows the existing furnaces by sizes in 1935 and 1938; the furnaces built since 1938 have all been large hearth diameter — approximately 15 units whose hearth diameters range 20 ft to 23 ft 6 in., 12 furnaces whose hearth diameter is 25 ft and 23 units with hearth diameter between 25 ft 6 in. and 27 ft 6 in.

The increase in furnace capacity required a corresponding increase in stove capacity. To make such stove capacity feasible checkers had to be much smaller in size. Since it takes approximately 500 square feet of stove heating surface per ton of iron, a 1300 ton furnace requires 650,000 square feet be provided. Another empirical method is to allow 7 to 9 square feet of heating surface per cubic foot of air blown per minute. This closely approximates the 500 square feet previously mentioned.

Small checkered stoves are possible only because gas cleaning has progressed to the point where gas can be cleaned between .01 to .02 grains per cubic feet very economically. The majority of the modern plants "fine clean" the gas with electrical precipitators.

Clean gas then has been responsible for being able to use highly efficient stoves in which the exit gases are under 300 F when straight line hot blast temperatures of 1400 to 1500 F are carried, and dome temperatures are held to a maximum of 2000 F.

With the larger stoves it was necessary to burn more gas, therefore the need of pressure burners went hand in hand with larger stoves. To supply the gas the stove burners would have to operate at 15,000 cfm. To illustrate the part clean gas has played, a modern stove burner will introduce less than 33 pounds of solids into the stove in 24 hours, most of which is very light material and blows through the stove.

Under the large checker, dirty gas combination, a stove using 8000 cfm of gas might receive 660 pounds of solids during a 24 hour period, a large part of which would remain in the stoves, since the dust particles are larger and would slag onto the walls of the stove, so that the stoves would require frequent cleaning.

Prior to 1920 pressure burners were practically unheard of. In the past years about 50 per cent of the stoves in the country have been equipped with pressure burners.

The operator of a modern plant is indeed fortunate when compared with the operator of ten years ago. One plant with which the writer is familiar produces 500 tons of iron per day and has only 115,000 square feet of heating surface in the four stoves. Stoves in this plant are on the furnace only 30 minutes, as compared with modern stoves which may be kept on blast 1½ hr. With small checkered stoves and low stack temperatures, sufficient draft is not always available from a stack of practical height, and an injector must be provided for use only when back-drafting the furnace.

The tendency has been definitely toward fully automatic charging, which assures the operator that the materials are going into the furnace in the quantity and sequence he desires. Automatic charging has progressed to the point where approximately 33 per cent

TABLE I.

Classification of Existing Blast Furnaces by Hearth Diameters

Hearth diameter, ft-in.	1935	1938
15-0 and less	53	31
15-0 to 20-0	128	115
20-0 to 25-0	74	81
25-6	1	4
26-0	2	2
27-0	2	2
28-6	1	2

of the operating furnaces in the country are equipped with full automatic or semi automatic charging.

Automatic control of blast temperatures has contributed much to uniform furnace operations. In hand controlled mixer lines the fluctuations of blast temperature were considerable, but the writer recalls an operation 20 years ago in which perfect straight line charts were made by the simple expedient of switching the thermocouple leads to a thermocouple located in the furnace stack, when a uniform reading of 1100 F was obtained. Due recognition must be given, however, to the value of recording instruments, properly maintained and properly housed, with little chance for tampering.

Hoist houses have received considerable study. All modern skip hoists are motor driven and are housed in buildings usually provided with a washed air fan system which keeps the house under pressure slightly higher than atmospheric pressure, thus excluding dust and dirt. Modern skip houses are being built with no windows and in lieu of the large doors for making engine repairs there are provided removable floor slabs for servicing the hoist and equipment. The maintenance man has been provided with adequate permanent trolleys for the easy handling of necessary repairs.

Mud guns have been, without exception, electric units on all of the furnaces recently built. These provide adequate clay capacity for stopping the iron notch under almost any condition.

Twenty-five years ago automatic stockline recorders were just a dream, while today 70 per cent of the furnaces are so equipped.

The uptake and downcomer systems have come in for their share of consideration, and these systems are being built today so proportioned that gas velocities are held under 30 feet per second.

Modern top gas temperatures are generally around 350 F, and uptakes and downcomers are no longer needed to be brick lined. A two-fold advantage is thus secured: The gas volume is reduced, due to greater heat losses, and this reduction in volume gives a reduction of velocity. The reduced velocity drops out more dust

Figure 3 — Chart showing average pig iron production per blast furnace operating, year by year.

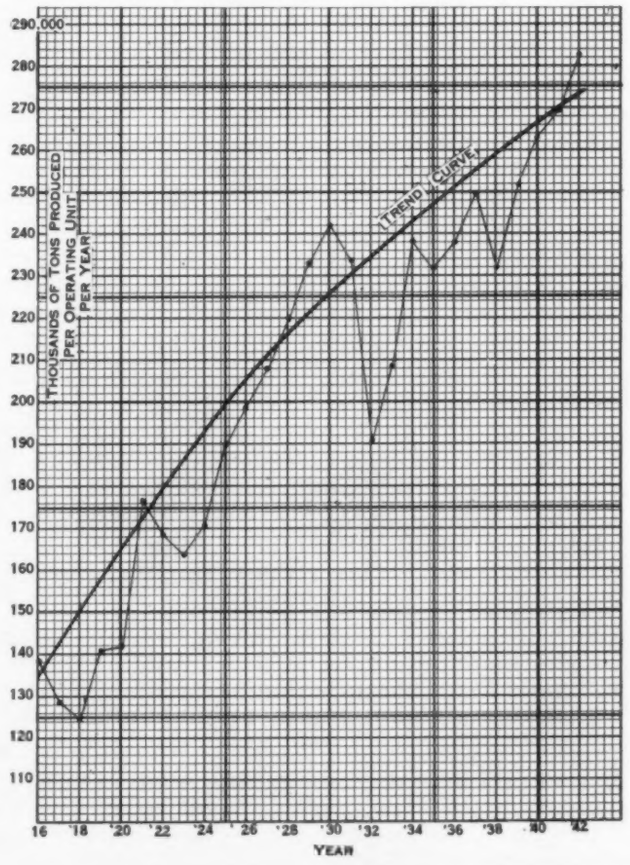
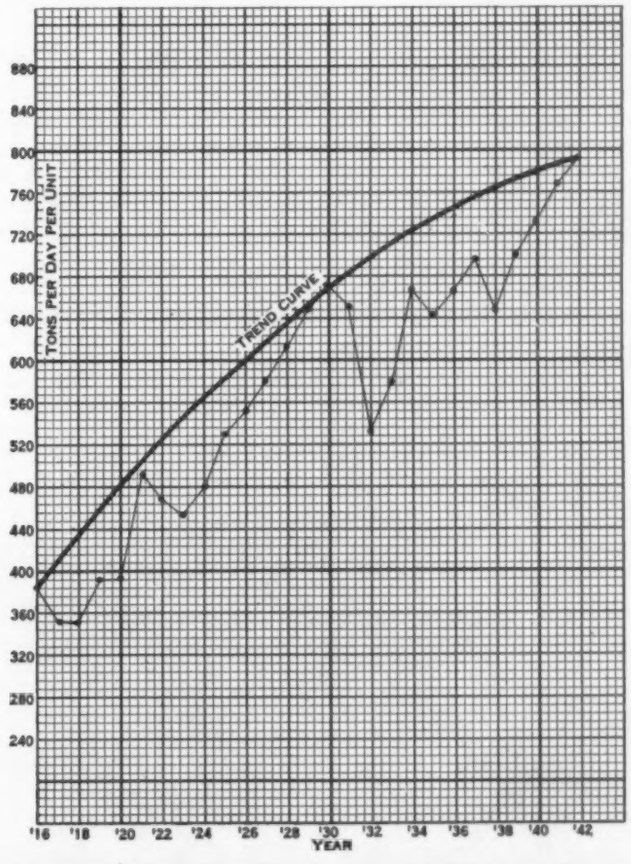


Figure 4 — The average daily production of pig iron per furnace operated shows a gradually increasing trend.



particles in the downcomer and reduces the work required of the dustcatcher. Another advantage of lining uptakes and downcomers with carbon steel plates instead of brick linings is a colder gas coming to the gas washer, thus requiring less water per thousand cubic feet of gas. This, of course, is desirable where water is at a premium. Since the benefits gained from wet gas cleaning more than offset the utilization of the sensible heat in the gas, it has not been necessary to brick line gas mains.

Pug mills under the dustcatcher have come in for their share of popularity, since they condition the dust and eliminate one of the dirtiest places around the furnaces.

The sizing of raw materials has been found to be particularly advantageous. Much has been accomplished by the sizing of coke and few plants today are operating without sizing coke to some degree. A few plants are leading the parade with excellent results and are sizing their ores and fluxes.

For a good many years sintering plants were looked upon as a nuisance to have around. However, in recent years their advantages have become recognized and these units are fast attaining their proper place. The increase in sintering has been brought about largely by the decrease in quality of raw materials and by the increased tonnage made possible by the use of sinter in the blast furnaces.

Modern plants are being built with thickeners for processing the water from wet gas cleaning equipment. These are being installed for two reasons: to recover the flue dust and because laws require that water emptied in rivers and lakes must be held under 8 grains of solids per gallon. The amount of recovered material from a thickener in a 1000 ton blast furnace plant will be in the neighborhood of 45 tons per day.

In reviewing the steady increase in the size of blast furnaces, as well as the operating characteristics and performance of the large furnaces which have formed our most recent construction, there is no reason to believe that furnaces with hearth diameters of 30-32 ft cannot be operated successfully. Such a furnace would have a stockline approximately as long as the hearths of our modern furnaces.

DISCUSSION

PRESENTED BY

F. E. KLING, Assistant Chief Engineer, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania

A. C. CUMMINS, General Superintendent, Carnegie-Illinois Steel Corporation, Youngstown, Ohio

P. V. MARTIN, Director of Industrial Relations, Carnegie-Illinois Steel Corporation, Chicago, Illinois

F. E. Kling: The subject has been covered pretty well; however, I disagree with cleaning the gas by the wet method. Although the latter has been developed to perfection in recent years, ending with an electric precipitator furnishing a very clean gas, the cost of installation is extremely high, being about half a million dollars for a large furnace. Also, the cost of operation is high — about five cents per ton of iron without fixed charges. The return on the investment is very small and may even be a debit after fixed charges have been deducted.

For a number of years I have advocated cleaning gas by the dry method, and have done a great deal of work along this line. Experiments are underway which indicate that gas, satisfactory for use under boilers, can be cleaned by an improved dust catcher. There are several dry methods whereby gas from an improved dust catcher can be cleaned to .05 grains or less per cu ft to be used in stoves. The cost of an improved dust catcher and final cleaner will be only one-half that of washing facilities and the cost of operation only one-fifth.

A. C. Cummins: We are all interested these days in what return we are getting for our investment, and also what output we are getting in proportion to the relative capacity of the units we are using in the manufacture of pig iron. It would be very interesting if Mr. Janecek could add an appendix to his paper on some constant basis of investment cost, and let us know what the installation cost per ton of capacity is today as compared with what it was twenty-five years ago. I think that the progress has not only been made in increased production with fewer furnaces, but perhaps if the figures were once put down, we would find that our investment cost per ton of capacity is no greater, if you corrected to a constant level of labor and material cost.

We hear a great deal these days about the difficulty of making additions or improvements to steel producing capacity because of the very large investment cost. And we hear some of the operators criticized because they promote refinements and elaborate installations that cost more money than perhaps the results they attain will justify.

I believe that the operators of our plants have an opportunity to justify what they do if the statistics can be established. And such statistics might have importance in influencing the development of the industry's facilities that undoubtedly will be necessary if the competition with other materials in the postwar period is to be a successful ordeal for steel.

P. V. Martin: I feel that it would be a bit unfair if we, as blast furnace operators, would let Mr. Janecek's last remark, that the trend will be to larger units, go unchallenged. It appears to me that operators should approach the installation of larger units with a bit of caution, because it seems to me that there have been very few good big furnaces that ever did as well as the good little furnaces. When you get up into the size of furnaces that we have today, the important items of cost are largely raw materials.

In my experience I believe I can say that, under similar conditions, our bigger furnaces generally have not equalled the performance, either in coke rate or tons per square foot of hearth area or even in losses, of the smaller furnaces. To me it appears as if the trend after the war, and driving for economy, is going to result or going to go in two directions. One of those is in improving raw materials, and if you will improve raw

(*Please turn to page 73*)

Shearing

FLAT ROLLED STEEL

. . . . although shearing is a relatively old process, almost no practical data have been available on the subject . . . . the test results presented here through the cooperation of the steel plant and the equipment manufacturer will prove to be of great value to everyone concerned with the shearing of flat rolled products . . . .

by F. E. FLYNN and **D. A. MacARTHUR**

DISTRICT MANAGER
REPUBLIC STEEL CORP.
WARREN, OHIO

CHIEF ENGINEER
WEAN ENGINEERING CO.
WARREN, OHIO

▲ IT has been assumed by many that shears of some type or other have been used for many thousands of years, but we have been unable to find any historical basis for believing that shearing is other than a comparatively modern invention. It is remarkable that, while the Greek poets from Homer on have mentioned blacksmiths' tools, such as hammers, tongs and anvils, and Greek vases show the blacksmith at work with his tools around him, in no case are any types of shears, or even iron cutting chisels, shown or mentioned.

A probable explanation is that in ancient times iron and other metals may have been so precious that no one would think of cutting them and thus allowing any to go for scrap. Therefore, the whole piece with which the worker started would be forged into the finished article.

There are, however, evidences that cutting was done in very ancient times by means of chisels. Egyptian bas-reliefs as early as 4000 B. C. show chisels being used for stone cutting and for ship building. An iron chisel with a case-hardened point, supposedly fabricated about 500 B. C., was dug up in Ceylon. In graves in Upper Austria, iron chisels thought to be as old as several centuries B. C. have been found. Daimachus, a Greek writer, of about the time of Alexander the Great (340 B. C.) refers to chisels made of a special kind of steel. As mentioned before, however, there is no evidence that these chisels were used for metal cutting, although, of course, some one may have done so.

The first mention we find of cutting iron and steel in any manner is in a book written about A. D. 1100 which mentions "cutting irons" for cutting iron and steel. (Theophilus — Roger of Helmershausen — "Schedula Diversium Artium") However, no description of them is given. The first shears or scissors for general use seem to have been invented in France about A. D. 1300, and soon became a general article of commerce. Chaucer refers to scissors, and Shakespeare and Bacon to shears.

The first definite record that shears of any kind were used for metal cutting appears in a book published in 1556 (Georgius Agricola, "De Re Metallica"), which states that metallic silver was cut either with an iron chisel pounded by a hammer, or with an iron tool similar to a pair of shears, with blades about 3 ft long. Figure 1 is a copy of the illustration appearing in the original book showing these shears.

For the next 200 years, we find considerable mention of shearing metal, particularly slitting. We find that slitting shears were used prior to 1590 in Sweden, and in that year the first mill built in England for slitting flattened bars into square nail rods was constructed by G. Bochs of Belgium. In 1606 and 1618 British patents were granted to Bulmer and Dawbeny for slitting metals driven by water power. In 1667, at Lynn, Massachusetts, charcoal iron plates were sheared into strips or square rods for wire drawing. About 1700,

Presented before A. I. S. E. ANNUAL CONVENTION, Pittsburgh, Pa., Sept. 25-27, 1944

Figure 1 — Illustration from "De Re Metallica" showing early methods of cutting metals.

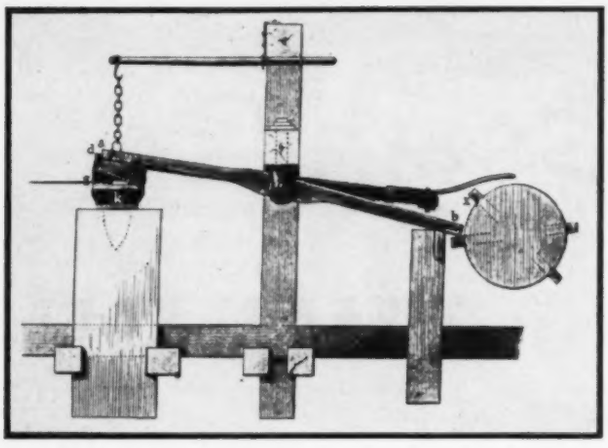


Figure 2 — Alligator shear constructed in Sweden shortly before 1794.

Memmendorfer near Nuremberg constructed heavy shears to cut metal plates a finger thick and six or seven feet long.

In 1734 we find mention of slitting machines on the principle of scissors, and also slitting mills in connection with rolling mills being used in Sweden, Belgium and England (Swedenborg, "De Ferro"). No illustrations of any of these early slitting shears or slitting mills seem to be available.

Dr. Samuel Johnson in 1774, when visiting an iron works, saw bars one inch or more square being cut by shears being driven by water power. No doubt these were guillotine shears of some type. The guillotine shear most remembered in history was of course introduced by the French Revolutionists in 1792 as a "humane" instrument of capital punishment. There is evidence, however, that this was not original, but was based on a similar instrument called the "maiden" used for the same reason during the Middle Ages.

The first modern design of metal cutting shears seems to have been constructed by Polhem in Sweden shortly before 1794. One of these was an alligator shear as shown in Figure 2. The other was a guillotine shear with inclined upper knife and parallel link motion as shown in Figure 3. Both of these shears were driven by water power (Beck, "Das Geschichte des Eisens").

In 1811, we find the first mention of shearing steel in Pittsburgh. Christopher Cowan built a slitting mill in connection with a rolling mill. A most intensive development of shears occurred after 1865. In that year J. Tangye constructed a hydraulic shear, and about the same time guillotine shears with inclined top blade driven by two cranks were perfected. In 1889, D. Edwards patented a double shear for cutting steel sheets with parallel edges.

In the 1880's and 1890's, emphasis was laid on heavy hydraulic shears for cutting thick blades or billets. One of the largest such shears was installed at the Carnegie Plant in Homestead in 1892. It would cut a billet 24 in. by 28 in. in cross section and had a piston 42 in. in diameter. The shear operated under a hydraulic pressure of 4000 psi.

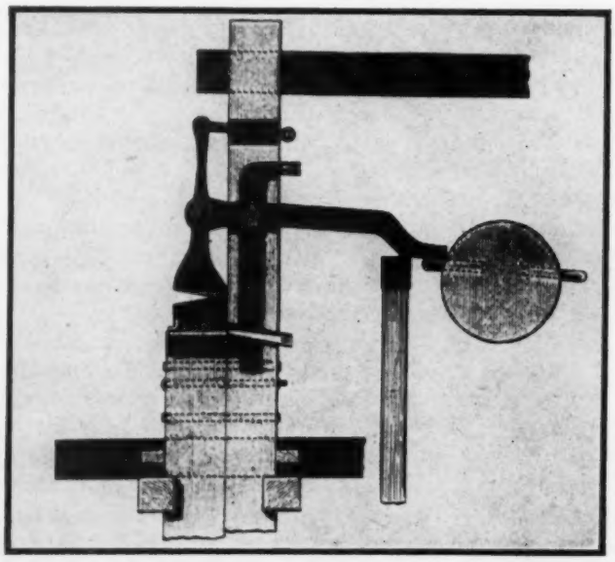
The first flying shear seems to have been invented by Victor Edwards of the Morgan Construction Company in 1892, and was installed in a continuous bar mill at Jones and Laughlin's plant in Pittsburgh.

It can be seen that from the very earliest times down to the present metal shears fell in two general classes —

1. Shears with straight knives.
2. Shears with circular knives.

In the early part of the 20th century, shears for use

Figure 3 — Early guillotine shear with inclined knife and parallel link motion.



in steel mills naturally improved, but until the advent of wide strip mills these improvements were mostly to be expected mechanical changes suggested by the expanding production in mills and the great increase in the number of shearing machines required.

SHEARS FOR STRIP MILLS

However, development of new equipment for shearing was given a great impetus by the construction of continuous strip mills. The great tonnages, and especially the long lengths produced, introduced new problems and made new types of shears necessary. The greatest need was for two general types of shearing operation:

1. Trimming or slitting shears to make accurate width strips, or to cut wide strips into narrow ones. The rotary shear naturally was ideal for this purpose.
2. Cutting-up shears to cut the long length strips into shorter pieces, more or less corresponding to sizes rolled by the older methods. For this purpose shears with straight knives were naturally used.

Rotary shears that could be used for trimming and slitting had been in existence for many years, and were readily adapted for handling material from wide continuous strip mills.

The earliest rotary shears utilized two arbors on which the knives were mounted, and could be used for any reasonable number of cuts. Knives were mounted either directly on the arbors and held apart by accurately machined spacers, or were mounted on some type of knife holder that was adjustable on the arbor. Obviously when extremely narrow widths were not necessary, the knife holder idea allowed more rapid changing of the width being cut, due to the fact that with the knife and spacer arrangement the arbor had to be completely unpacked and repacked to obtain a different width of cut.

Although a great many more or less ingenious designs were used, the knife holders proved very difficult to use and still obtain high quality of cut edge and accuracy of width. Although adjustable knife holders are still used on many rotary shears, especially for slow speed cutting of light gauge steel such as tin plate, the so-called packed arbor has proved more dependable for high speed multiple cutting of widely varying gauges. A good example of packed arbor slitting is shown in Figure 4.

As mentioned previously, the packed arbor arrangement has the disadvantage of requiring a considerable length of time to change widths of material. The best solution of this difficulty seems to be the use of two complete cutting units consisting of housings, arbors, knives and spacers, thus allowing a second unit to be completely packed ready for use while material is being run on the first unit. The slitter shown in the illustration is arranged for this method of operation. By disconnecting the couplings, which are underneath a guard in the background, the slitter unit complete with its base can be lifted from the sub-base, which is grouted into the foundation, and in a very few minutes the second unit, with completely packed arbors, installed.

Several mills have been arranged to use this scheme with two sizes of slitting units; one for light gauge and one for heavy gauge. For instance, the unit illustrated has 9 in. knives, and the sub-base and drive are so arranged that a similar unit and 12 in. knives, and of course larger arbors and bearings, can be installed if desired.

Two factors led to the design of a new type of rotary shear:

1. The long time necessary to change widths on an arbor type machine.

Figure 4 — The packed arbor has proven more dependable than adjustable knife holders in high speed multiple slitting of widely varying gauges.

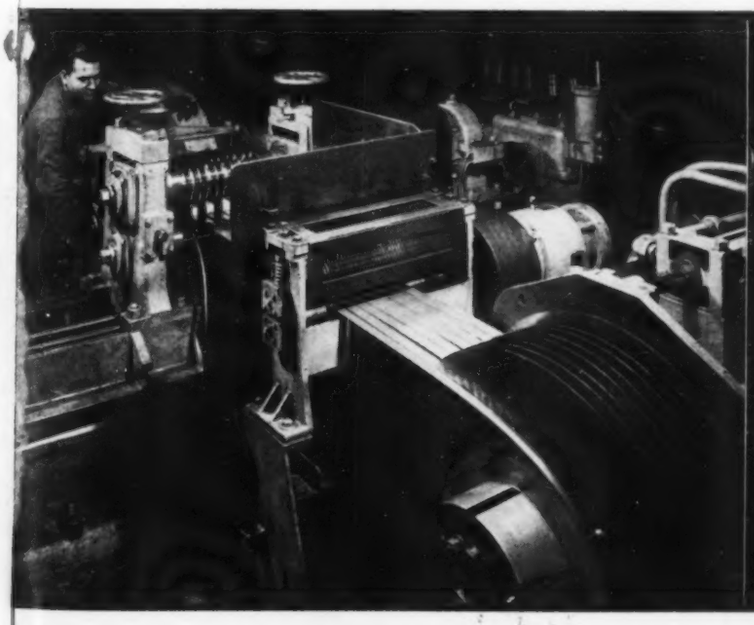


Figure 5 — In the movable housing side trimmer knife arbors are held solid in two heavy housings which can be moved toward or away from each other to adjust width.

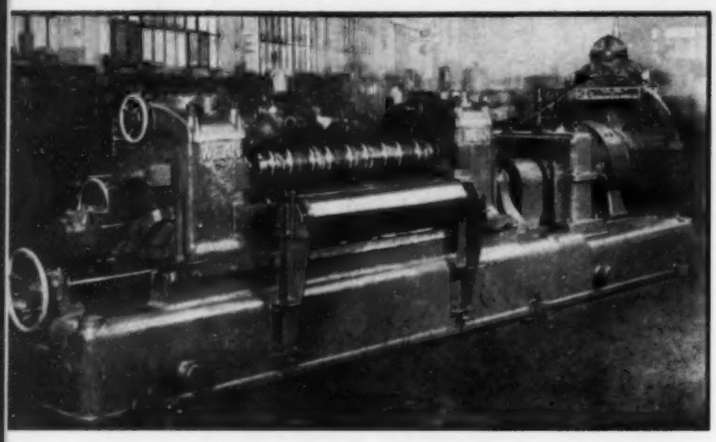


Figure 6 — Shop view of a combination of movable housing side trimmer and packed arbor slitter.

2. The fact that a very large percentage of strip mill product required side trimming only, and did not need to be slit into multiple narrow strips.

The result of careful consideration of these facts was the design of the movable housing side trimmer. One of the best of these is shown in Figure 5. In a movable housing side trimmer, the knife arbors are held solid in two heavy housings. These housings can be moved toward or away from each other without disturbing in any way the relationship of the two opposing knives. Therefore, width changes can be made in a small fraction of the time necessary even with the best arrangement of packed arbor slitter.

Early designs of movable housing side trimmers still used arbors for driving the knives opposite the motor side of the machine, even though the knives were held on the housings. With this design, sizes could be changed easily and readily, but knife changing was still rather difficult. With the design shown in Figure 5, it can be seen that the knives can be removed and replaced after grinding with a minimum of difficulty.

Naturally a need existed at certain plants for a combination of movable housing side trimmer and packed arbor slitter. Such a unit is shown in Figure 6. The side trimmer is a unit identical to that shown in Figure 5 arranged so that a pair of packed arbors can be inserted between the movable housings when it is desired to slit multiple strands.

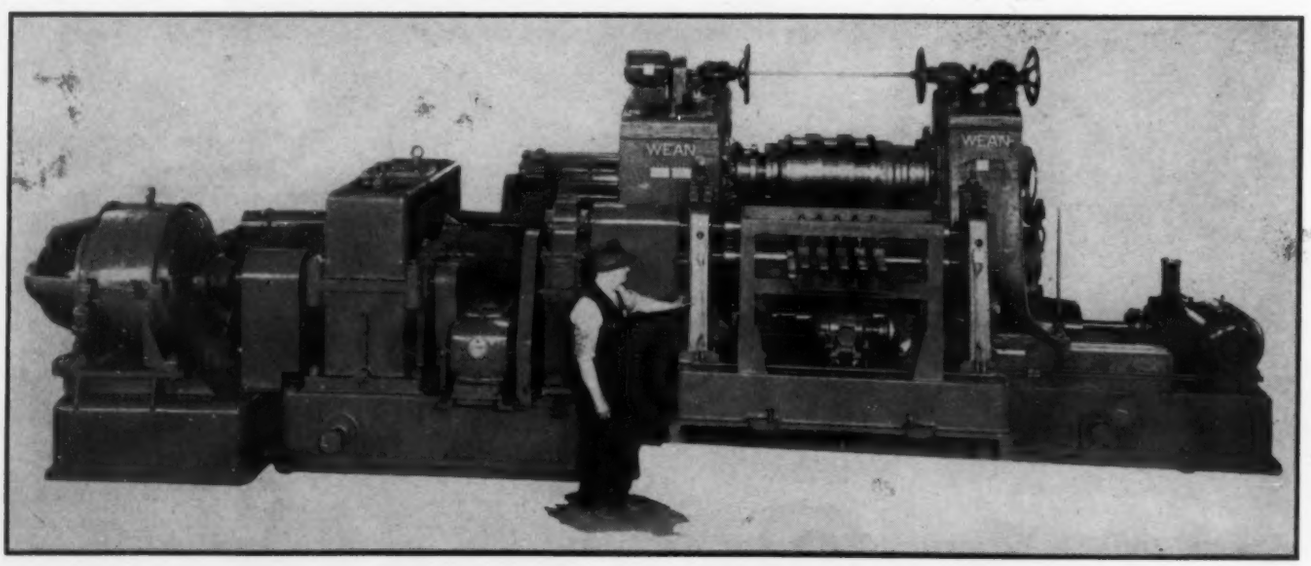
Still another variation of this design is shown in Figure 7, which is a movable housing side trimmer with permanently installed through-arbors, sliding through hollow housing arbors on the side farthest from the drive.

It is possible to use such a machine with both the side trimming knives, which are mounted on the housings, and slitting knives mounted on the arbors in action at the same time. The machine in this illustration is obviously much heavier than the previous machines illustrated, and is capable of making four cuts in $\frac{3}{8}$ in. thick steel plate.

The advance in design of cutting-up shears has been even more spectacular than the advance in rotary shears. Naturally the early cut-up shears were standard squaring shears of conventional design with some type of gauge device for measuring the length of cut. The shears would be actuated either by hand or by means of a trigger touched by the work piece. A surprising number of such units are still in operation, even though the production is necessarily small and the accuracy is not of the best.

The next step was to use a roller feed-in device of some type which would run to measure a desired length of strip and stop to allow the stationary shear head to cut, then automatically start again to measure another piece. Although such units are still in operation at some mills, production was not much more than for the

Figure 7 — This variation of combination unit is a movable housing side trimmer with permanent through-arbors sliding through hollow housing arbors on the side farthest from the drive.



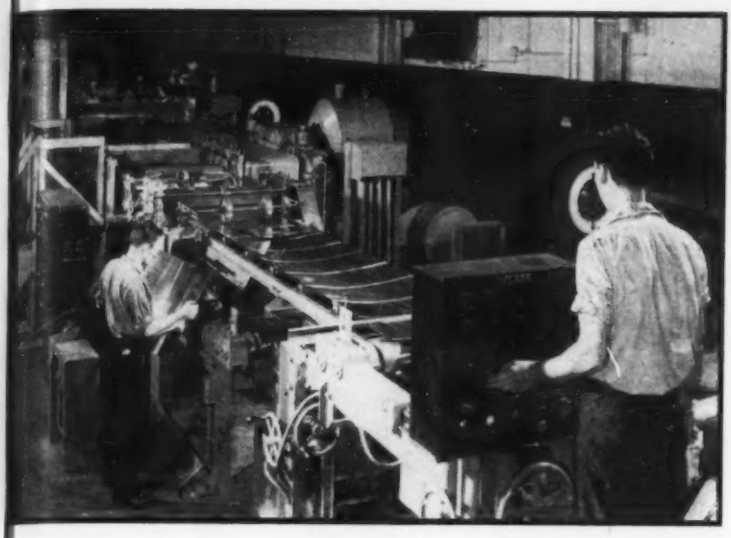


Figure 8 — The high operating speeds of flying shears necessitate careful design in handling and piling equipment for the cut pieces.

cruder gauger lines, and accuracy was quite poor. Some of the earlier attempts in this design had great trouble keeping to an accuracy of several inches plus or minus.

The need for flying shears for cutting up coils of strip was so obvious that several made their appearance early in the development of wide strip mills. The necessity of cutting an almost infinite number of possible lengths considerably complicated their design over hot mill flying shears which had been in existence for many years. Most of the early strip flying shears were either quite inaccurate or very undependable, and usually both. However, at the present time, which is after all a very few years since the first strip flying shear was built, high speed synchronized shears are available for all gauges of steel strip that can be coiled on hot strip mills, and are capable of speeds up to 1000 fpm with an accuracy much better than is required for usual commercial tolerances. In fact, much material cut up on the best of these flying shears used in connection with a well designed rotary trimming shear is sold as re-squared product without further shearing.

One of the most remarkable flying shear operations is the cutting up of steel for tin plate. Shears are now available for doing this operation at 1000 fpm for most commercial lengths, and at an accuracy of $\frac{1}{32}$ in. Consider this against the best unit in operation 12 years ago, at a maximum speed of approximately 45 fpm and an accuracy of within not more than $\frac{1}{8}$ in., often worse.

It is interesting to note that these shears actually make five to seven cuts per second when operating at top speed, which of course necessitates great care in the design of handling and piling equipment for the cut pieces, such as illustrated in Figure 8.

Use of trimmers and flying shears as described obviously necessitates development of much new auxiliary equipment, and led to the installation of complete lines of equipment for shearing, rather than the purchase of a shear only and installation of miscellaneous equipment that could be picked up to handle the material to and from the shear. A very long paper could very well be presented on the various types of shear lines, and we feel this can be best presented separately, so will pass over the very large subject of shear line design with no more comment.

FORCES INVOLVED IN SHEARING

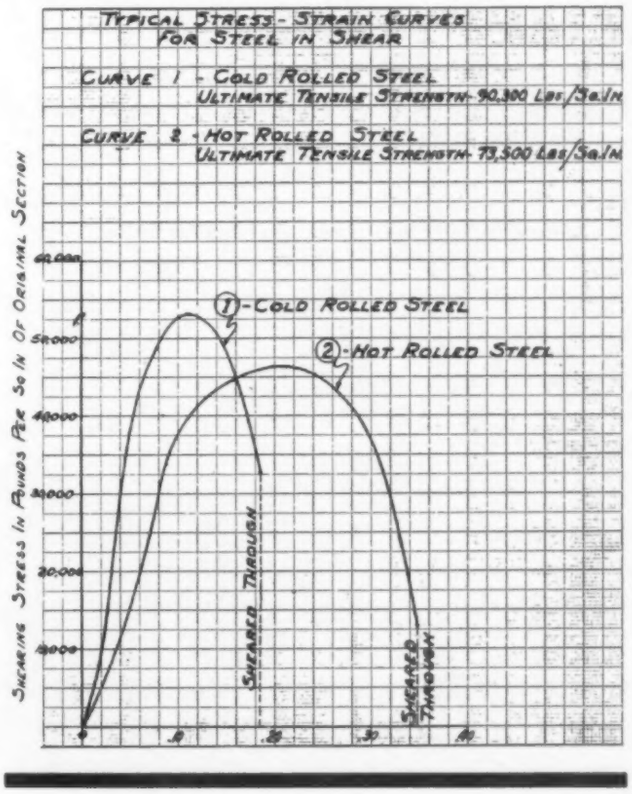
It can be seen that the changes in shear design brought on by continuous strip mills did not change the two fundamental types of shears, i.e., shears with straight knives and shears with circular knives. Formula for stresses and power involved in shearing with straight knives can be stated with considerable confidence, and have been checked for the most part by actual tests. However, since very little data of particular value to steel mill engineers seems to have been published we will present some fundamental shearing data for this type of shear.

Shears with straight knives can be sub-divided into two distinct types:

1. With knives parallel to each other.
2. With knives inclined to each other or having rake.

The most prominent example of practical shears with knives parallel to each other is rotary flying shears, also scrap choppers used in connection with rotary slitting shears which are usually built on the same principle as rotary cutting up shears. Almost all other shears, including flying shears of the guillotine type, are built with a certain amount of rake on the knives, which obviously decreases the maximum force required for shearing.

Figure 9 — Typical stress-strain curves for steel in shear. Curve 1 is for cold rolled steel of 90,300 psi ultimate tensile strength. Curve 2 is for hot rolled steel of 73,500 psi ultimate tensile strength.



In shearing with parallel knives, the force on the shear knives depends on the shear strength of the material cut, and on its cross-sectional area. The shear strength is usually ½ to ⅔ the ultimate tensile strength, the fraction being higher for the softer kinds of steel than for the harder ones. In Figure 9 are shown typical stress-strain curves obtained from tests for hot-rolled steel and for cold-rolled steel in shear. These curves were obtained with test specimens ¾ in. square for curve (1) and .54 in. square for curve (2). It is interesting to note that the shearing is completed and the force drops to zero when the knife has cut through only 35 per cent of the thickness in the case of the hot-rolled steel, and even less, or only 18 per cent of the thickness, in the case of the cold-rolled steel; also, that while the maximum stress is greater for the latter, the area under the stress-strain curve is greater for the former, which means that the hot-rolled steel required a smaller maximum force but a greater amount of power for shearing than the cold-rolled steel.

For a cold-rolled strip, .01 in. thick x 30 in. wide, of the characteristics corresponding to curve (1) in Figure 9, the maximum force would be simply 53,700 psi x .01 in. x 30 in. = 16,110 pounds.

Some years ago, the impression prevailed that the force did not increase in proportion to the area sheared, or that the apparent shearing strength per square inch decreased greatly in the thicker material. Other shear tests made at that time, however, definitely disproved this; in certain plates hot-rolled in the same mill, the trend was the other way, the shearing strength increasing from 36,000 psi in the plates ⅛ in. thick to 44,000 psi in plates ¼ in. thick. However, these results cannot be taken to represent the general rule; and it is generally safe to regard the shearing strength as independent of the thickness.

There is a slight speed effect in cold-shearing, resulting in some increase of force as the speed of shearing is increased, but just as in other kinds of cold deformation, the speed effect is negligibly small.

More important is the effect of friction of the material rubbing against the side of the shear knife as it penetrates, and this force is included in all of the test figures given.

Now we come to the consideration of the forces in shearing with inclined knives, or knives with "rake," as in the case of guillotine shears. At first thought it would seem that we could calculate this very simply on the basis of the assumptions indicated in Figure 10. If R is the rake, or the tangent of the angle of inclination of one shear knife to the other, then the length L in the illustration is equal to thickness t ÷ R. At point (3), the knife has just begun to penetrate, and this corresponds to the left-hand end of, say curve (2) in Figure 9. At point (5), or 22 per cent penetration, the maximum shear stress is reached, while at point (6) or 35 per cent penetration, the force should have dropped to zero, and the two parts of the plate should have been entirely separated from each other at this point. Hence if we take the average stress over the length, .35L (which for curve (2), Figure 9, is 73½ per cent of the maximum stress, or 34,300 psi), then it would seem that the shearing force should be:

$$F = 34{,}300 \times \frac{.35\ t}{R} \times t = 12{,}000\frac{t^2}{R} \quad \text{or}$$

$$F = 0.257 S_s \times t^2/R. \qquad (1)$$

To test the correctness of this equation, an extensive series of shear tests was made some years ago by W. Trinks and J. D. Keller covering a range of plate thickness from ¼ in. to ⅛ in. and with rake from 1:8 to 1:32. The results are shown in Figure 11. The tests showed that the shearing force ranged from ⅓ more to a maximum of over 3½ times the values given by equation (1), the increase being greater the thinner the plate and the larger the rake. From this it is evident that Figure 10, is far from representing truly the actual conditions during the shearing process.

Two factors are accountable for the increased shearing force. The first is the force required to produce the bending or permanent curvature of the sheared plate. This, however, is small compared to the true shear forces. It produces a slight off-setting of the forces on the two knives. This effect is indicated in Figure 12.

The second factor is the spreading out of the shearing stress over a considerably greater part of the length L than the 35 per cent assumed on the basis of Figure 9, curve (2). What happens is that, instead of shear failure

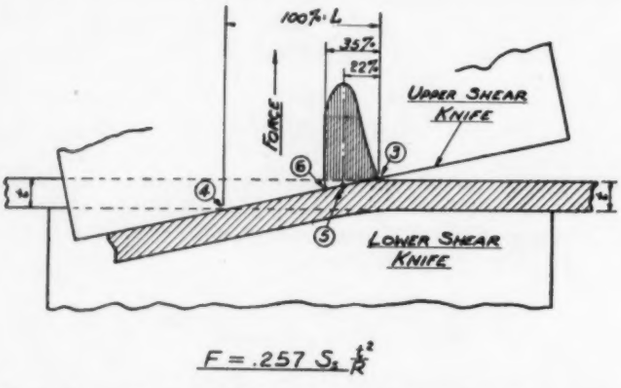
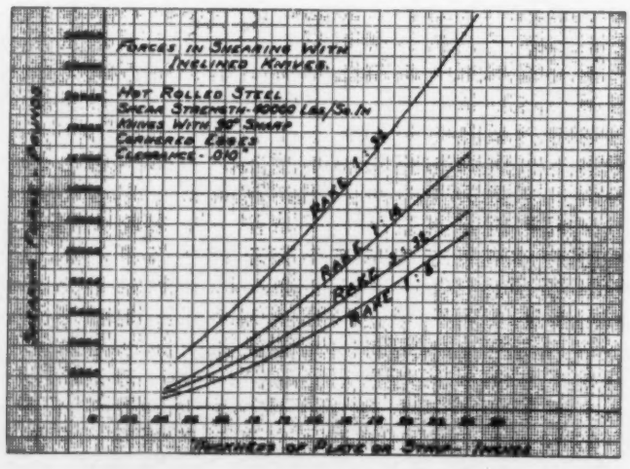


Figure 10 — First analysis of apparent effect of rake of the shear blade.

▲

Figure 11 — Curves showing forces in shearing various gauges with various rakes on the shear blade.



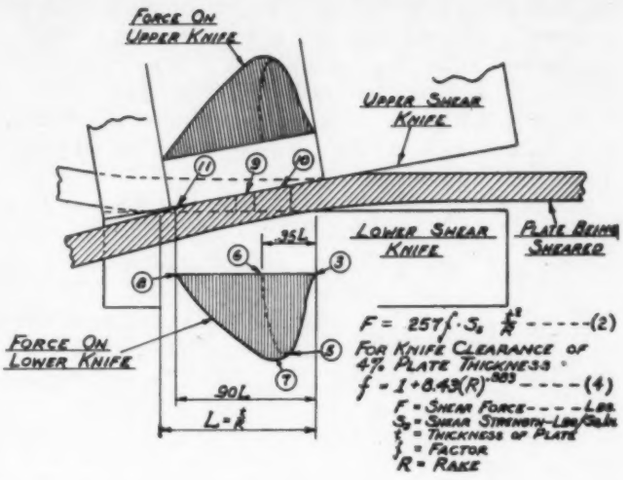


Figure 12 — Complete analysis of forces on shear knives, including consideration of bending of the plate and spreading of the stress. (above left)

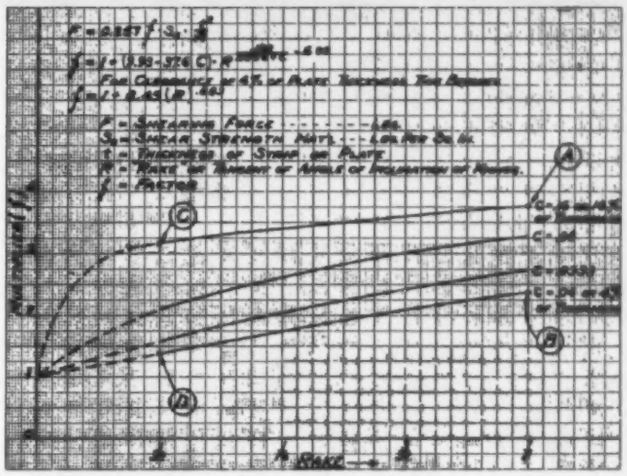
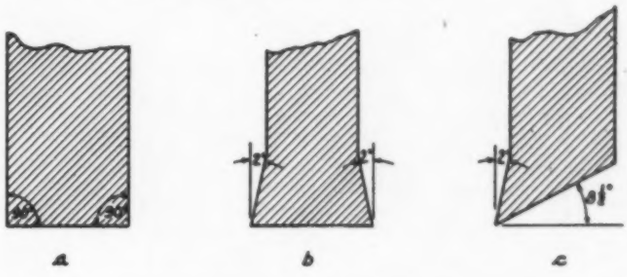


Figure 13 — Curves showing value of factor f for various rakes of the shear blade. (above right)

Figure 14 — Shearing force can be reduced by providing a side clearance angle as in b, and further reduced by a top rake angle, as in c. (below)



occurring all at once as in the case of parallel knives, those parts of the area subjected to stress, which are nearly sheared through and are approaching final failure, (such as element 9 in Figure 12) are buttressed by the other parts adjacent them which are still far from failure (such as element 10), and are thereby kept from final shearing apart until considerable further penetration of the knife has occurred. The result is that the length over which resisting stress is exerted is stretched out from .35L to perhaps .90L or almost 1.00L in some cases, and the total force is then proportional to the area enclosed above curve (3)-(7)-(8) in Figure 12 instead of the area above curve (3)-(5)-(6) as previously assumed.

The buttressing action is obviously greater for large rake, while for small rake the conditions approach more nearly those of parallel knives. This explains why the factor, by which equation (1) must be multiplied to make it agree with the test results, increases with the rake. It does not explain why the factor increases as the thickness is decreased.

The effect of the thickness is explained by that of the clearance. In the tests, not all of the dimensions were geometrically similar, inasmuch as the lateral clearance between the vertical sides of the inclined shear knives was constant (.010 in.), whereas for geometrical similarity it should have decreased in proportion to the thickness. In other words, the clearance in per cent of the thickness actually increased inversely as the thickness. Increased relative clearance means less sharp shearing, giving a chance for those parts which are nearly sheared through (such as 11, Figure 12) to bend down into the gap and thus hang on longer, possibly finally failing by a tension action rather than by true shear. It also spreads the resisting force over a still greater percentage of the length L, or possibly even over a length somewhat greater than L.

The test results of Figure 11 can be represented by the equation:

$$F = 0.257f \times S_s \times \frac{t^2}{R} \qquad (2)$$

where F = shearing force, pounds; S_s = shear strength of the material, psi; t = thickness of plate or strip, inches; R = rake, (or tangent of angle of inclination of the knives to each other). The factor or multiplier f is given by the empirical equation:

$$f = 1 + (9.93 - 37.6c) \times (R)^{\frac{.199}{.0936+c} - .005} \qquad (3)$$

in which c is the lateral clearance between the knives in ratio to the plate thickness.

For 4 per cent clearance or c = .04, this reduces to:

$$f = 1 + 8.43(R)^{.885} \qquad (4)$$

Figure 13 is a curve with values of (f) for various clearances plotted against rake. As in the case of any empirical equation, (3) and (4) should not be extrapolated too far beyond the range of the tests from which they were derived. For design purposes, the forces calculated from these equations should be increased by about 20 per cent to allow for the effect of rounding of the shear knife edges due to wear.

So far, all figures have applied to the case of shear knives with sharp 90 degree edges as (a), Figure 14. The tests showed that it is possible to reduce the force by providing a side clearance angle and also a top rake angle. With 2 degree side clearance angle, as at (b) in the illustration, the force was reduced 5 to 12 per cent

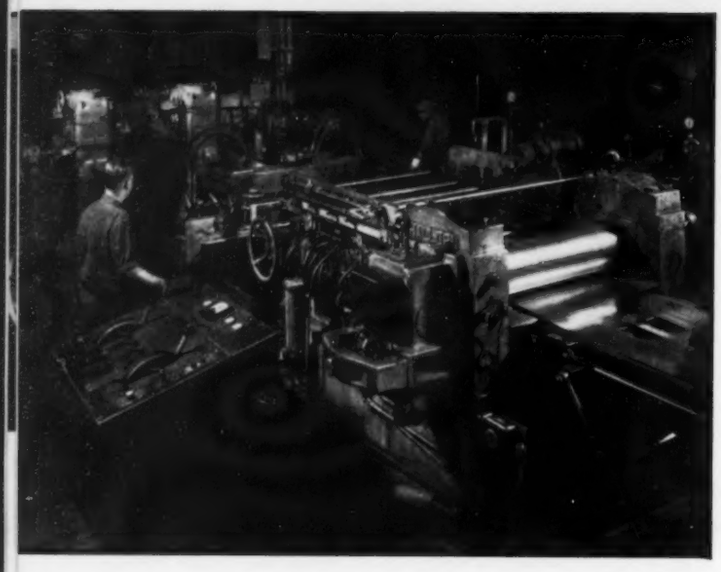
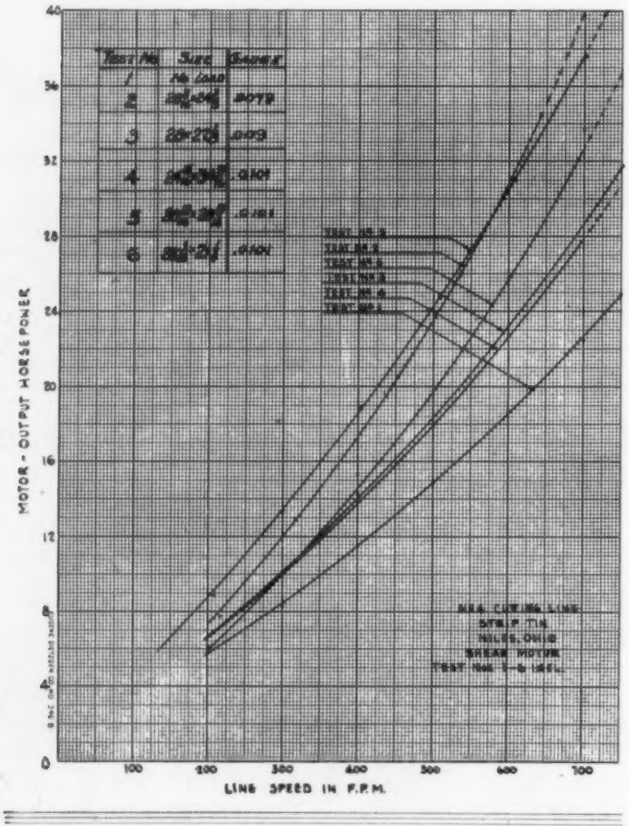


Figure 15 — High speed tin plate flying shear line upon which one series of tests was run.

▲

Figure 16 — Curves showing results of tests which were run on the shearing line shown in Figure 15.



as compared with (a), while with 2 degree side clearance angle and 8½ degree top rake angle, as at (c), the force was reduced 10 to 22 per cent as compared with (a). But because of the difficulty of grinding the shear knives otherwise than with 90 degree edges, the more efficient forms such as (c) are seldom used.

Our investigations definitely disclose on extremely interesting variation of the sharp 90 degree knife edge. At one plant it has been found that slightly dulling the cutting edge of the female knife when side trimming tin plate will throw almost all of the burr onto the side scrap, leaving a very clean edge on the good strip. On practically all side trimming set-ups, this is, of course, the bottom knife. No one has been able to explain why this is true, but repeated tests by different operators on different machines seem to indicate that it is a definite fact. This method has been satisfactorily used on gauges up to .025 in.

Another fact which may not be new to shear knife companies is that softer knives seem to give more satisfactory results on high carbon steel than do the hardest knives which are universally used on mild steel. The hard alloy knives seem to break and chip when cutting the high carbon steel. One plant stated that they had to forge some knives in their own shop because they couldn't purchase soft enough knives from any shear knife company to shear certain material going through their plant.

POWER REQUIRED FOR SHEARING

For shears with parallel knives, the energy absorbed in shearing is simply (average stress×area×distance of penetration of the shear knives when final shearing-through occurs). It is, of course, proportional to the area under the shearing stress-strain curve such as shown in Figure 9. For curve 2 of that figure, the average stress under the curve is 73½ per cent of the maximum stress or "shearing strength" S_s, and the distance through which the force acts is 35 per cent of the thickness, hence the energy used up in shearing is, in inch-pounds:

$$(.735 \times S_s) \times (\text{width } w'' \times \text{thickness } t'') \times (.35 \times t'') = 0.257\, S_s \times w \times t^2$$

For curve 1 of Figure 9, that is to say, for steel hardened by cold rolling, the energy consumption in inch-pounds is $0.136\, S_s \times w \times t^2$.

If v is the speed of the shear knife in feet per minute and w is the width of plate inches, the maximum instantaneous horsepower is:

$$\text{Hp (max.)} = \frac{w \times t \times v \times S_s}{33{,}000} \qquad (5)$$

while the average power requirement if the shear cuts N times per minute is:

$$\text{Hp (avg.)} = \frac{w \times t^2 \times N \times S_s}{1{,}540{,}000} \qquad (6)$$

for hot-rolled steel.

In numerous cases, the power exceeds the values figured from these equations, when conditions are such that the plate or strip does not shear through completely when the knives have penetrated to 35 per cent of the thickness, but instead the two parts continue to hang together until a considerably greater penetration has been reached. This is particularly noticeable in the case of the scrap chopper, to be discussed later on, in which the strip is not held down but enters at a considerable inclination to the plane of the blade, so that the cut is made somewhat diagonally instead of straight through the thickness. The penetration apparently may

be as much as 90 per cent or even 100 per cent of the thickness before shearing-through occurs, and the power consumption is increased accordingly.

Equations (5) and (6) give the net power required for the actual shearing work. To this must be added the friction work, which depends on many factors including design of the shear, type of bearings, alignment, lubrication, temperature of operation, and size of shear with respect to area or thickness of material being sheared. When strip of nearly the maximum size for which shear is designed is being cut, the friction horsepower in well-designed machines is comparatively small, seldom exceeding 25 per cent of the net hp, but since the greater part of this friction power is consumed whether the shear is under load or not, it will be evident that when cutting thin gauges of strip on a large shear, the friction power may exceed by several times the true shearing horsepower.

In shearing with inclined knives, the shearing force is constant as the knives penetrate and the cutting zone travels across the plate, except near the beginning and near the end of the width where the force is smaller because the full shearing wedge does not exist.

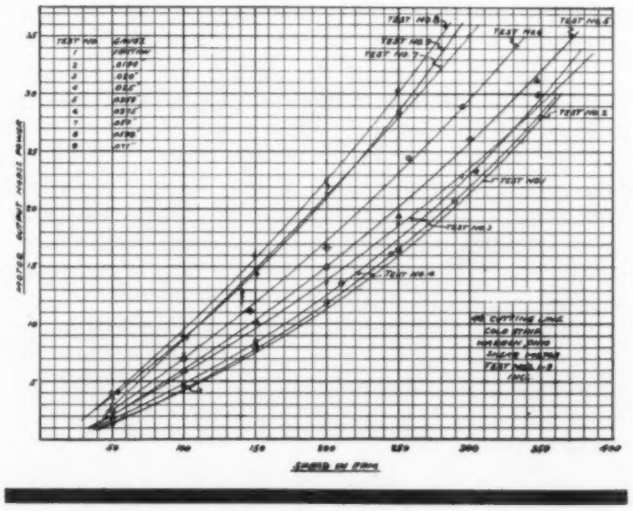
The vertical distance traveled by the moving blade is $(t+w\times R)$. The average power consumption in the case of hot-rolled steel is:

$$Hp\ (average) = \frac{k\times F\times(t+w\times R)\times N}{396{,}000} \qquad (7)$$

where F is the force read from Figure 11 or calculated from equations (2) and (3) or (4) and k is slightly less than unity, but seldom less than .90.

Figure 17 — Sheet shearing line upon which another series of tests was conducted.

Figure 18 — Curves showing results of tests run on the sheet shearing line illustrated in Figure 17.



TEST DATA SHEARING WITH STRAIGHT KNIVES

As will be discussed in detail later in this paper, we made a rather extensive series of tests on side trimmer and slitting units in order to check theoretical calculations of power. More or less incidental to these rotary shear tests, several series of tests were run on different types of flying shears.

One series of tests was made on a high speed tin plate flying shear line, which is pictured in Figure 15. The results of the tests are shown by the curves in Figure 16. Another series of similar tests was carried out on a 350 fpm shearing line for cutting 48-inch maximum width strip into sheet mill sizes. This line is pictured in Figure 17, and the results of the tests are shown by the curves in Figure 18. It should be noted that these tests follow fairly closely the results obtained by H. W. Poole and presented in his paper "Motor Applications and Power Requirements for Strip Processing Lines," A. I. S. E. 1942 Proceedings, page 450.

Due to the fact that modern flying shears, such as those used in the tests, have so much gearing to obtain proper synchronization, and that a leveling stand is universally used both for flattening strip and feeding it through the shear knives, it is impossible to check these power tests against the theoretical formulae given heretofore, which take into account shearing only.

This is also illustrated quite clearly by the curves on Figures 16 and 18, which show that the heaviest and widest material does not always require the most power. This is doubtless due to the setting of the leveling rolls and the shape of the strip used in each particular test. Obviously if the piece of strip requires more leveling to give a satisfactory product, more power will be required, even though actual shearing power may be less. These tests should be of considerable value in computing actual motor requirements for such shears, but we have not attempted to correlate them with any theoretical data.

However, one set of tests was made on a scrap chopper in connection with a side trimming unit. For each strand of strip there is one stationary straight knife and two parallel knives mounted on a rotating arbor. The design of the scrap chopper was the same as the one shown in front of the side trimming shear in Figure 19, except that it had a separate motor drive which allowed accurate power tests for chopping only to be made.

Going back to equation (6), which gives the average power required for shearing with straight knives, we have prepared Figure 20.

Solid line (1) is plotted from that equation, with 4 hp added to each point to make gross horsepower, since the actual tests showed approximately 4 hp idle load on the scrap chopper. This line would be theoretically true if the material broke after being sheared through 35 per cent of its thickness.

We then plotted line (2), showing the theoretical gross horsepower assuming the material was not sheared through until the knives had cut 100 per cent of its thickness.

There is ample reason to feel sure that material sheared in such a unit does not break off when the knives have passed through 35 per cent of its thickness. It must be remembered that the material is fed into the knives at an angle and is not held in any way before the knives touch it. Observation of the sheared ends of a considerable quantity of scrap showed considerable variation in the point at which the material appears to break, but also indicates that the shearing is usually much more than 35 per cent of the thickness.

From the results of approximately 50 tests, we have plotted points on Figure 20. There can be seen the considerable scattering of points, which, for such a unit, could be expected. However, practically all of them lie within the maximum and minimum theoretical lines, and most of them lie nearer the maximum than the minimum.

Thus, for this type of scrap chopper it would appear that we can safely say the power will be something less than the line drawn for 100 per cent shearing.

It must be noted that the horizontal scale for Figure 20 is based on thickness squared times the width which is in accordance with equation (6). The tests shown were made on many different thicknesses and widths, and when an attempt was made originally to plot the points on the basis of area only, there was a very much greater scattering than is shown in Figure 20. Obviously a ¼ in. strip 2 in. wide has the same area as a ½ in. strip 1 in. wide, but will not require nearly as much power to shear.

This points out another reason for the scattering of points as they were finally plotted, since scrap from some tests might easily have twisted 90 degrees before being cut, thus making the power considerably more than if it had laid flat.

Our observations indicate that scrap choppers of this type have, in general, been overpowered, and these tests may be of benefit for future motor applications.

CALCULATIONS OF FORCE AND POWER FOR ROTARY SHEARS

When we consider the other general type of shears, that is, shears with rotary knives, little early test data were available and very little theoretical data seem to be published. We found that many designers seemed to have methods of their own for figuring power and stresses, not all of which agreed with each other.

With regard to the forces involved, tests would be quite difficult to obtain on commercial equipment so we will present the following theoretical data, which we believe is sufficiently accurate for most purposes. Later when we discuss power for rotary shearing, we will present both theoretical data and extensive test data.

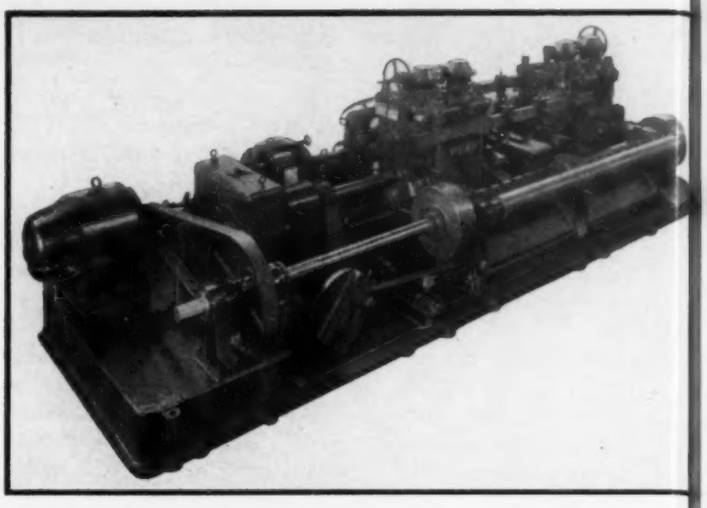


Figure 19 — Shop view of side trimmer with belt driven scrap chopper.

For rotary shears, it has been a general rule for many years that the thickness of strip should not be more than $^1/_{70}$ of the shear knife diameter, and this does not appear to be a bad rule in actual practice. However, in making our tests material was sheared, with every appearance of entire satisfaction, up to approximately $^1/_{57}$ of the knife diameter on two machines having widely different diameter of knives.

Obviously thicker material requires greater forces for cutting, and therefore much larger bearings and arbors must be used, which itself increases knife diameter, and it is our thought that the space required for bearings of sufficient capacity should be the limiting feature in deciding upon knife diameter, rather than an arbitrary figure such as mentioned above.

A formula for figuring forces and horsepowers for rotary shearing was developed as shown in Figure 21. Referring to the diagram in this figure, it is evident that the shearing action will, or at least may, extend from the beginning of contact of the knife with the strip at one end leftward to point 3, at which the circles representing the periphery of the knives intersect.

This diagram is drawn showing the knives with a slight amount of overlapping. Actually on some thicknesses of material this over-lapping might be negative, in which case the shear action will extend almost to the vertical center line through the axis of the two knives.

The shearing stress in the strip will be distributed along the length w in a manner similar to curve (2) of Figure 9, and this curve has been shown in broken lines on the diagram. However, due to the shape of the rotary knives, there will be a more rapid penetration near points 1 and 2 and less rapid penetration near point 3 than for straight knives. Therefore, the curve will be modified approximately as shown in the cross-hatched area on the diagram.

The force F required to produce shearing is equal to the average stress times the shearing length w times strip thickness t. The average stress equals the maximum stress, or the shearing strength of the material, times K. This gives:

$$F = KS_s \times w \times t \qquad (8)$$

Factor K is found to range from .66 to .75. The line of action of this force will pass through the center of gravity of the cross-sectioned stress area, and will be at a distance L from the center line of the knives. In Figure 21, let:

$$x=\sqrt{R}\sqrt{(t+y)}, \text{ where R = radius of knife}$$

and $x'=\sqrt{R\times y}$

then $w=(x-x')$

$$=\sqrt{R}\ [\sqrt{t+y}-\sqrt{y}] \tag{9}$$

since, $L=x'+kw$ (10)

$$=(1-k)\times\sqrt{Ry}+k\times\sqrt{R(y+t)}$$

It can be shown that factor k ranges from .444 to .545, and since the strip speed is approximately equal to the peripheral speed of the knives, the equivalent velocity of force $F=v\times\frac{L}{R}$. We can then substitute in the formula:

$$Hp=\frac{2\ FV}{33{,}000}\times\frac{L}{R} \tag{11}$$

or F and L giving:

$$Hp=\frac{2\ S_s\ v\ t\times K}{33{,}000\times R}\left[\sqrt{t+y}-\sqrt{y}\right]\times\sqrt{R}$$

$$\times\left[\ (1-k)\sqrt{y}+k\times\sqrt{t+y}\ \right]\sqrt{R} \tag{12}$$

It is evident that $\sqrt{R}\times\sqrt{R}$ in the numerator cancels the R in the denominator, which means that the horsepower is independent of the shear knife diameter. This does not agree with some formulae that have been used in the past, but does seem to agree very well with test results.

Equation (12) looks extremely complicated, but by calculating many numerical examples, it was found that, using the values of K and k corresponding to any given values of t and y, the last part of equation (12), included in the dotted lines on Figure 21, works out to practically constant value in all cases, and that equation (12) then reduces itself to:

$$Hp=\frac{S_s\ v\ t^2}{45{,}000}, \text{ for both knives, per cut,} \tag{13}$$

where S_s = average stress
v = velocity of strip, fpm
t = thickness of strip, inches

This means that the net power consumption is proportionate to the maximum shearing stress of the material, to the strip speed, and to the square of the thickness.

Equation (13) should give the maximum power required for shearing with rotary knives. It would appear that the only way this power could be exceeded would be due to very incorrect knife clearances. On the other hand, when shearing hard, cold rolled steel, the material presumably should shear through before point 3 is reached, and the power consumption should be less than shown in equation (13).

POWER TESTS ON ROTARY SHEARS

Realizing that such equations as given above are very difficult to prove and probably would not find wide acceptance without supporting data, we arranged for a rather extensive series of tests on rotary trimming shears. In many respects this simply carried on the work done by Mr. Poole as previously mentioned. We

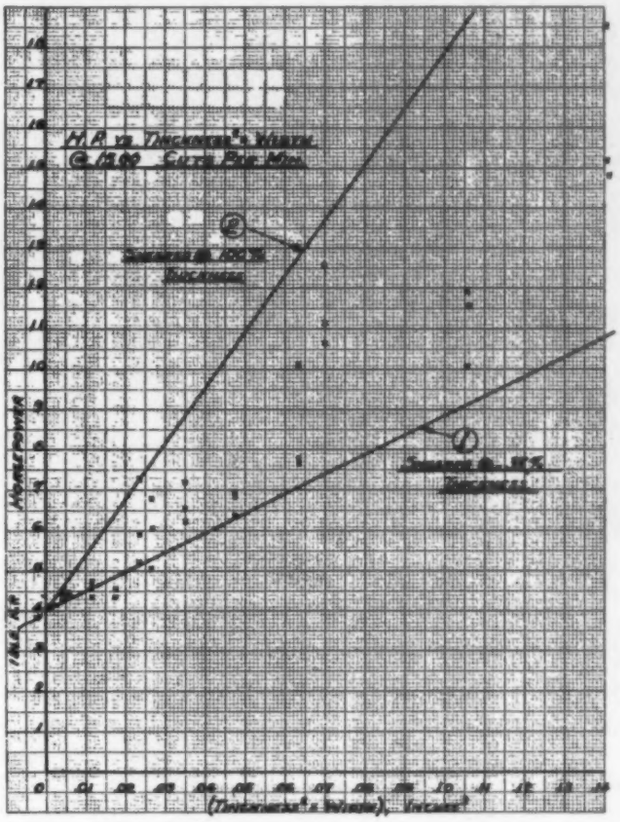
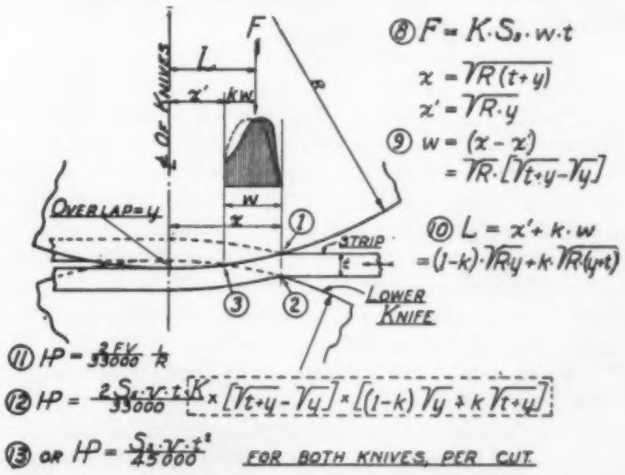


Figure 20 — Chart showing the results of tests on scrap chopper, with calculated limits.

▲

Figure 21 — Chart showing development of formula for calculating forces and horsepowers in rotary shearing.



consulted with Mr. Poole, and he urged us to carry on these tests, stating he was fully aware that the original tests made by him did not cover enough points to give an absolutely sure picture of the power requirements. He also turned over to us all of the data he obtained in preparing his paper, both the data which was used and that which he rejected. All of this proved of extreme benefit to us, both in outlining the type of tests we should perform and in interpreting the results.

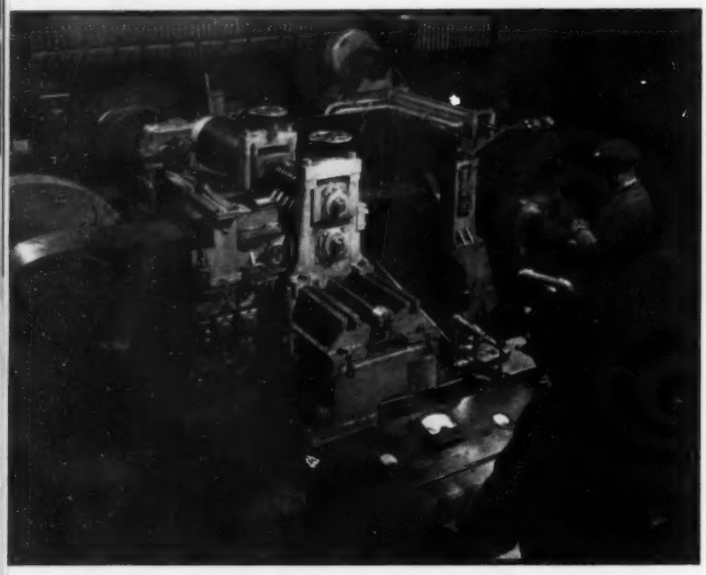


Figure 22 — Gang slitting line upon which tests were run.

The first series of tests were made on various designs of slitting lines in six different steel mills and were made under actual production. Three or four tests were made on each line, thus gathering a considerable amount of data. However, since practically every one of these units had some kind of a friction device in the line, it proved impossible to plot any understandable curves.

We believe the data obtained will be of considerable interest and probably of much value to designing engineers. It is tabulated as an appendix to this paper.

One definite conclusion can be drawn from these tests; that is, in order to obtain accurate and reliable engineering data, it is necessary to set up the machine or the line for a test, and not simply read desk ammeters during normal production.

One additional test was made on a gang slitting line similar to some of the six lines previously mentioned, this being No. 27 gang slitter at the Warren Plant of Republic Steel Corporation. The line is illustrated in Figure 22. The line is designed to gang slit material 20 in. maximum width to 5 in. minimum width, .070 in. maximum gauge to .015 in. minimum gauge, into 9 coils at a maximum rate of 1000 fpm. The coil holder and reel are arranged to handle 8000 lb coils. The line consists fundamentally of an uncoiler, a slitter equipped with pull-out rolls and a winding reel.

The uncoiler is of the expanding drum type having a minimum diameter of 15 in. and a maximum diameter of 21 in. Expanding and collapsing of the drum is accomplished by means of a 3 hp, 220 volt, 3 phase reversing a-c motor. A manually adjusted drag brake on the uncoiler induces a slight drag on the strip entering the slitter, and a quick acting solenoid-operated brake holds tension in the strip when the line is stopped.

The slitter is driven by a 50 hp, 1150/1440 rpm, d-c motor, capable of making 10 cuts in .070 in. gauge, .40 carbon steel strip running at a speed of 500 to 1000 fpm. The slitter is equipped with a set of pinch rolls at the exit side to pull the steel through the slitter knives to the reel in threading a coil in the line. A 3 hp, 220 volt, 3 phase, a-c gear motor drives one of these pull-out pinch rolls through an over-running clutch during threading, while the other pinch roll drives a tachometer generator which is used both to indicate strip speed, and to function in conjunction with the amplidyne controlling the speed and tension of the winding reel. The strip is guided into the trimmer by a roller guide type feeder table with hard maple drag blocks preceding the roller guide.

The slit steel is wound uniformly on the winding reel by maintaining constant tension of the reel. The reel head is of the expanding-collapsing type, 16 in. in diameter by 24 in. wide, driven by a 100 hp, 300/1000 rpm, a-c motor. It is capable of handling an 8000 pound coil having a maximum outside diameter of 48 in. and maximum width of 20 in. A hydraulic system provides a means of expanding and collapsing the reel head, and of stripping the coils off the reel onto an unloading ram located adjacent to the reel head.

The slitter motor can be used either to drive the slitter by power when cutting, or can be disconnected by means of a throw-out clutch and all slitting power obtained from the reel.

It can be seen from the above that there is a friction drag brake on the coil holder, which means that the total power into the line may vary considerably even for the same number of cuts due to the heat taken by the friction brake.

Production and operating data on this gang slitter is as follows:

Average production of line — 2.1 tons per hour
Acceleration 0 to 600 fpm — .12 minutes
Deceleration: Line stop 600 to 0 fpm — .085 minutes
Emergency stop 600 to 0 fpm — .025 minutes

Crew required to operate line:

Title	Duties
Slitterman or operator, main desk	
1st helper	Bands coils and removes from reel.
2nd helper	Loads coils on coil holder (Not used)
	Total, 3 man crew

In usual operating practice slitter is not driven when slitting steel over .035 in. gauge but is driven when slitting lighter material to prevent tearing and buckling in the slitter knives.

One of the tests run on this machine under power slitting, that is with the slitter motor putting in a certain amount of power, is illustrated in Figure 23, where horsepowers are plotted against speed in fpm. The dotted lines on the curve show the power output of the slitter motor and, as can be seen, show such a variation as to be almost worthless. However, when power readings of the reel at the same time were added to the slitter motor power, the solid line points were obtained.

We have drawn lines between points without attempting to draw an average curve, but as can be seen, the points came together considerably and at least indicated that the general trend was a curve concave upward.

Another series of tests was made on the tin plate shearing line mentioned previously, and pictured in Figure 15. The results of plotting horse power against line speed in fpm are shown in Figure 24. As can be expected on such a line, the load curves for different types of material vary extremely little, but here again the same trend can be noted — that is, a fairly regular curve concave upward.

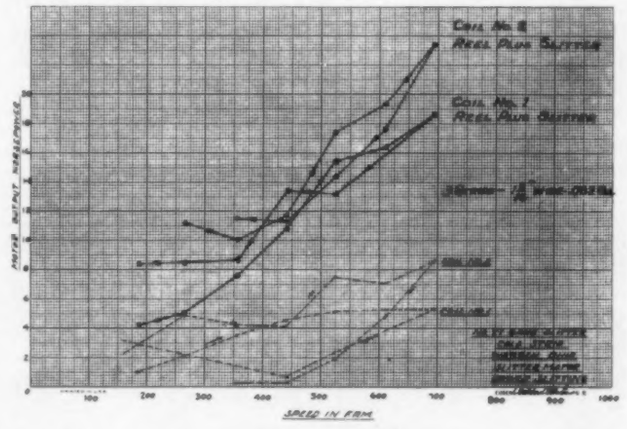
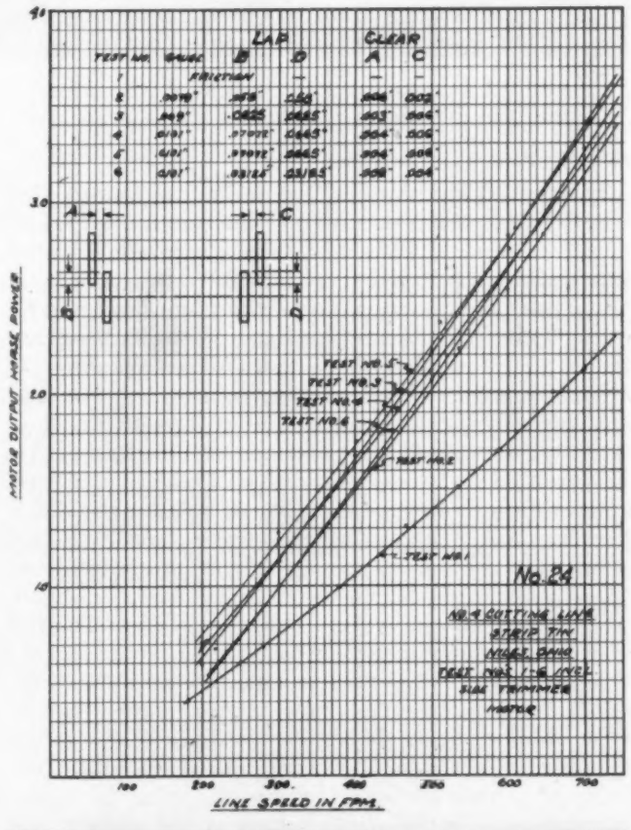


Figure 23 — Test results of gang slitter shown in Figure 22. Dotted lines show power input of slitter motor only. Solid lines are for slitter and reel combined.

▲

Figure 24 — Additional test results on tin plate shearing line. Load curves for different types of material show little variation.



Operating data on this line is as follows:

Average production of line — 10.5 tons per hour
Acceleration 0 to 700 fpm — .25 minutes
Deceleration: Line stop 700 to 0 fpm — .16 minutes
Emergency stop 700 to 0 fpm — .07 minutes
Measuring sheets to determine accuracy of cut:
75 sheets measured from ordered cut length 34 3/8 in.:
9 sheets measured 34 11/32 in.
50 sheets measured 34 3/8 in.
16 sheets measured 34 13/32 in.
Average sizes and gauges cut on this line:
Gauge — .0101 in.
Width — 27 in.
Length — 28 in.
Crew required to operate line:

Title	Duties
Operator	Main control desk
Inspector	Piler
2 helpers	1 at uncoiler; 1 at piler
Scrapman	Scrap baller

Another series of trimmer tests was made on a heavier gauge cutting line which was mentioned previously, and is illustrated in Figure 17.

Operating data on this line is as follows:

Average production of line — 7.0 tons per hour
Acceleration 0 to 350 fpm — .2 minutes
Deceleration: Line stop 350 to 0 fpm — .06 minutes
Emergency stop 350 to 0 fpm — .045 minutes
Measuring sheets to determine accuracy of cut:
30 sheets measured from ordered size 18 3/4 in. x .093 in. x 102 1/4 in. long:
20 sheets measured 102 1/4 in.
1 sheet measured 102 3/8 in.
4 sheets measured 102 5/16 in.
5 sheets measured 102 7/32 in.
10 sheets measured from .0144 in. x 29 1/4 in. x 114 1/4 in. long.
5 sheets measured 114 1/4 in.
5 sheets measured 114 5/16 in.
Crew required to operate line:

Title	Duties
Operator	Main desk
Inspector helper	Piler and inspector
2 helpers	1 at conveyor; 1 at uncoiler
Scrapman	Scrap baller
	Total, 5 man crew

Figure 25 shows the results of this test. Here again all of the curves show the same characteristic shape as previously mentioned. Some rather peculiar results were observed in that power required to shear some of the thinner material was considerably greater than power for heavier material. Not enough repeat tests were made to give absolutely sure explanations of all of these apparent discrepancies, but variation in knife settings, analysis and hardness of the material, as well as method of setting the guides in the machine, seem to account for most of it.

For instance, for some of the thinner material, where the power was quite high, the guides were actually

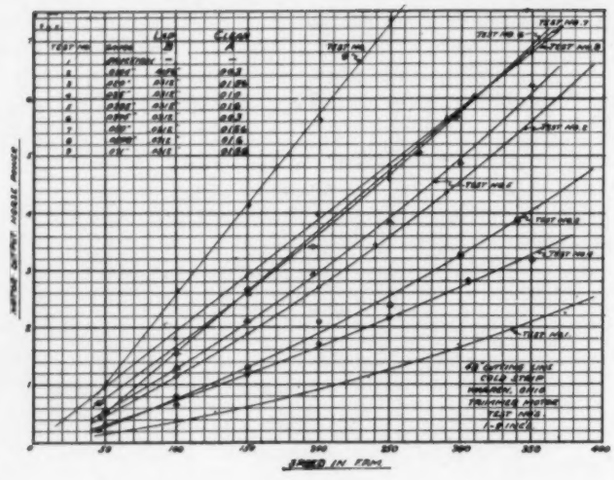


Figure 25 — These results from a series of trimmer tests on heavier gauges show some unexplained variations.

hammered up against the knives before the machine was started, and although this same condition was true when we took the no-load test, it is quite possible that when material was being sheared, knives deflected slightly and the friction of the guides was much more than when no material was being cut. Total power was in any case quite low on all of these tests which show apparent discrepancies, and would not materially affect the motor horsepower selected for a machine.

Incidental to the power tests, an attempt was made to determine relative strip speed and shear knife peripheral speed on the side trimmer shown in Figure 17. This was done by holding a hand tachometer, fitted up to show lineal speed, first on the knife then on the strip. So far as could be read, there was no difference in speed between the knife surface and the strip.

Every care was taken in these tests at Republic to get the best possible results, and an outline of the procedure is as follows: In outlining the test program required to obtain the desired data, a careful study of previous tests was made. As is well known, there are a great many inconsistencies found in what previous data has been made available, so an attempt was made to set up a procedure that would give more consistent results.

First, many previous tests made by the electrical companies in various plants were handicapped because they could not interrupt production, so many power curves with two or three speeds versus horsepower points were taken. Obviously a slight error in one or two points, and these errors are bound to creep in, can and has affected the entire shape of the curve of speed vs horsepower. It was deemed fundamental that curves with at least five points, and preferably seven points, were absolutely necessary for good results.

Then again, taking only one set of test readings was necessary in practically all previous tests, again being a condition that was dictated by the necessity to not interrupt production. In our tests, at least three series of test readings for each speed point were made, each of the three points completely calculated, and then the average of the three readings used for the curve. In this way, a reading that was missed badly could be spotted and discarded as false.

Also, many test readings were taken from the permanently mounted bench board instruments that were not always provided with scales that could be read to a very high degree of accuracy. It is no secret that many of these bench board instruments do not have their accuracy too well maintained, and after several years of use, may be as far as 10 per cent off the correct reading. This is no handicap to operations, but obviously is not satisfactory for a test such as we proposed to run.

Therefore, all readings were taken with instruments especially set up for this purpose. All current readings were taken with checked and certified millivoltmeters and shunt leads, and all millivolt readings were corrected according to the correction curve provided for the meters. Standardized and certified voltmeters were used in the same manner for the voltage readings.

Figure 26 — A shop test was also run on a side trimmer, where the test would not interfere with production.

It was quickly realized that a standard method of calculating output horsepower at the various speeds and voltages found in these tests was absolutely essential so speed horsepower curves made from one unit could be compared with speed horsepower curves made on other units. Several large electrical companies were contacted on this problem. Considerable discussion brought out the opinion of the men concerned that the method set forth by Mr. Poole in his paper was an excellent compromise method that appeared to be satisfactory. It is realized that this method of calculation is not good enough for a motor design engineer, but this method is close enough for an application engineer, and certainly gives much more accurate results than can be obtained by estimating motor efficiency at each speed and load.

The calculation method used is as follows: The full load losses for motor current consisting of commutating field, armature, series field and brush I^2R, motor bearing friction and windage, core loss and brush friction were obtained from the actual test data of the motor manufacturer. Those losses were then corrected for each value of current and speed by assuming that the motor current losses varied as the square of the current, the

motor bearing friction and windage losses were considered to vary as the 1.5 power of the motor speed, the core loss as the 1.5 power of the speed and the brush friction directly as the speed. The total losses were calculated for each value of current and speed, and subtracted from the total power input to the motor to give the motor out-put, or the input horsepower to the machine in question. As stated before, these assumptions are the best approximations that we could make, but the results are a great deal more accurate than attempting to estimate motor efficiencies at the very wide range of speed and loadings that are encountered during the tests.

As all motors involved were treated in the same manner, direct comparison between all our test readings is possible, even though the tests were run on different machines.

After studying the tests made at Republic, it was decided that still further tests would be of value, and the difficulties encountered by the men at Republic led them to suggest that additional tests be made, if possible, on an isolated machine which could be used for several days at a time without interrupting production in a steel mill, and also with a predetermined group of test pieces, all as nearly as possible of the same analysis and treatment.

After considerable discussion, a side trimmer just completed in the shop was selected to make this test. Due to the fact that a coil holder and reel were not available, it was decided that cut pieces approximately 20 feet long would allow the motor to come to equilibrium and give satisfactory power results.

Wooden tables were built on each side of the trimmer, and 20 ft lengths of 8 different thicknesses of steel ranging from .010 to .167 were obtained from Republic. All of this steel was as nearly as possible an average mild steel, cold rolled annealed and temper passed, having a Rockwell hardness of approximately 50.

The electrical equipment used to drive the side trimmer was so selected that tests over a wide range of speed could be secured. Equipment available at the plant, providing the above requirements, was as follows:

Item A — Side trimmer motor:

One 10 hp, 1150/1725 rpm, 230 volt, shunt wound, frame 66-T, ball bearing d-c motor.

Item B — Variable voltage motor generator set consisting of:

One 40 kw, 1750 rpm, 250 volt, shunt wound generator.

One 1 kw, 1750 rpm, 250 volt exciter.

One 60 hp, 1750 rpm, 220/440 volt, 3 phase, 60 cycle squirrel cage motor.

Item C — Control consisting of:

One d-c manual d-c motor starter.

One generator field rheostat to adjust voltage.

One motor shunt field rheostat.

By the combination of voltage and shunt field control, an over-all speed range of 410 to 1650, rpm equal to 190 to 765 fpm was secured.

As a means of getting accurate readings of the tests, a portable oscillograph was used. The instrument used provided four galvanometer readings:

1. For the 60 cycle timing.
2. The d-c voltage.
3. The d-c amperage.
4. The motor rpm.

The motor speed was secured by means of a portable Weston tachometer generator applied to the motor shaft.

Besides the oscillograph and its tachometer, one voltmeter, one ammeter and a hand tachometer were used to make visual readings for each test. The hand tachometer was used to set the speed for each test. This test in progress is shown in Figure 26.

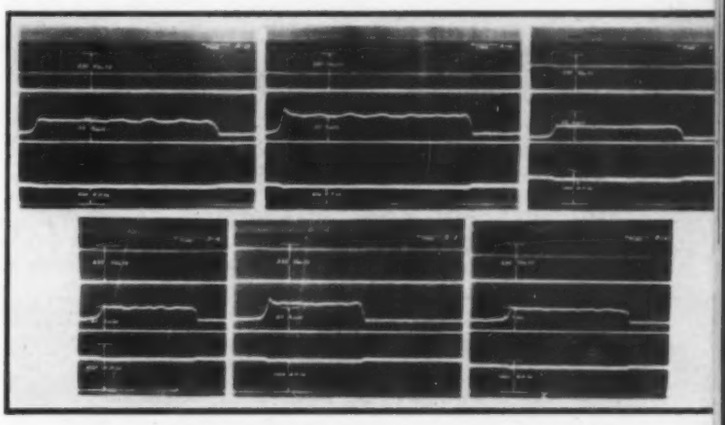


Figure 27 — Typical set of oscillograph records from test on side trimmer.

In running the tests, approximate speeds of 520 rpm, 830 rpm, 950 rpm, 1250 rpm and 1650 rpm were selected to provide at least 5 points for each curve. In each case four of the five points were repeated, making nine tests on each piece. The complete test consisted of one hundred and ten individual tests. A typical set of oscillograph films are shown in Figure 27. The various oscillograph films were then developed and calibrated.

After the tests were complete, the motor was tested in the shop on a dynamometer at the speeds used when shearing. Thus, exact out-put power for a given kw input for each test reading could be determined.

As a check against the calculations used on all other tests, we also calculated the out-put power for this set

Figure 28 — Curves of horsepower vs strip speed for various gauges in side trimmer.

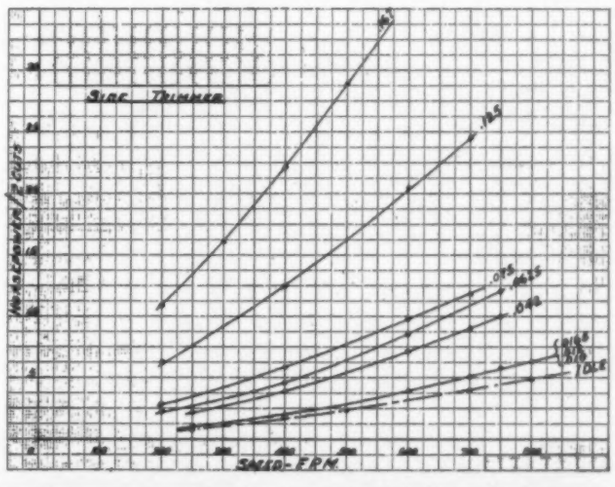
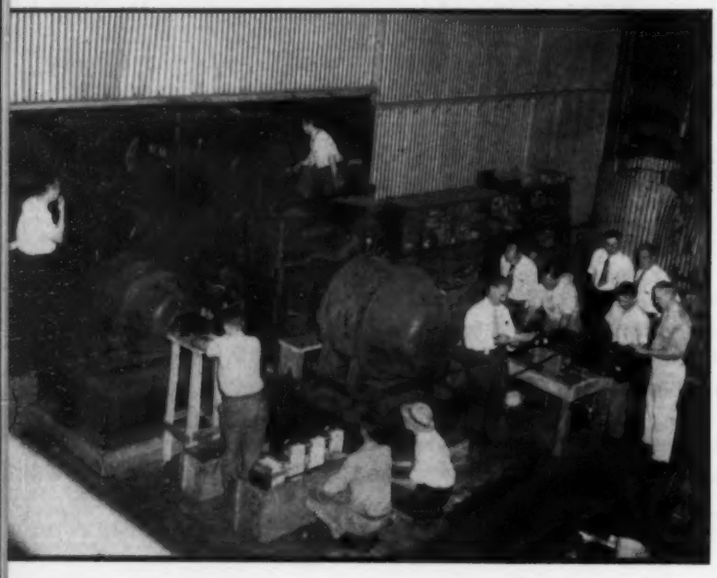


Figure 29 — View of heavy side trimmer upon which tests were run on heavy gauge material.

Figure 30 — View showing test set-up on the side trimmer shown in Figure 29.



of tests, and found that the values obtained varied only 2 to 4 per cent from the dynamometer valves, thus assuring us that the out-put horsepowers shown on the other tests were very close to correct.

A tabulation of the 110 tests was made showing amperage, voltage and rpm with the motor idling and the same factors with the motor loaded.

Curves of horsepower plotted against fpm obtained from this test are shown in Figure 28. All the points lie remarkably well on a smooth curve, all of which if extended would pass through the zero point, and practically all curves have at least 5 points, which leaves very little question as to their general shape.

It is interesting to note that the curves obtained at Republic are all slightly concave upward. As could be expected from the tests shown on Figure 24, the curves for the three lightest gauges lie so nearly on top of one another that we have drawn only one line.

Another interesting feature of this test is the fact that the machine used was identical to machines used in a large percentage of all steel mills to side trim tin plate, and yet it proved perfectly capable of trimming .167 in. mild steel without any sign of hesitation or overstressing. We believe this for the most part indicates the very wise wish on the part of steel mill engineers and operators to use equipment capable of doing several times as hard a job as it is usually asked to accomplish.

We might mention also that this last machine was identical to both trimmers tested at Republic Steel Corporation.

After studying these tests, it appeared that we had very good information on material up to .167 in. in thickness, but no data on trimming thicker material. Therefore we made arrangements with Youngstown Sheet and Tube Company to conduct a complete test on a heavy trimmer capable of cutting $\frac{3}{8}$ in. material.

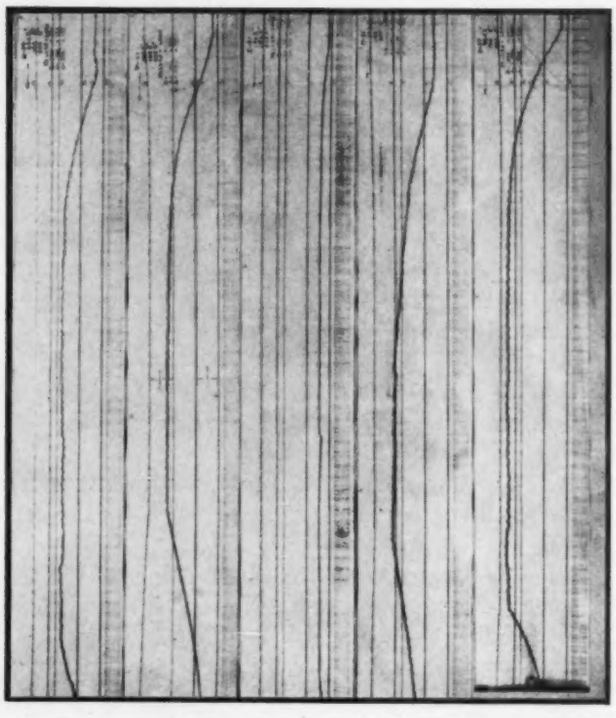
This machine is installed at their Indiana Harbor plant in the hot strip mill department, and is in constant use side trimming cut pieces of hot rolled strip steel up to $\frac{3}{8}$ in. thick. The machine is shown in Figure 29 with a piece of $\frac{3}{8}$ in. material being sheared. Obviously tables and other handling equipment for the material were available, thus making it an ideal place for our test.

The test being run is shown in Figure 30. Due to the very large size of the installation, some signalling means was necessary between the instrument men and the line operator. This explains the man to the left of the picture with the whistle in his mouth. The three meters shown at the bottom of the picture are used to record speeds, volts and amperes on the scrap chopper. The scrap chopper tests have been discussed previously in this paper.

The material selected for this test was as nearly as possible of the same analysis and hardness as used on the test in the shop, and was of 5 thicknesses varying from .075 to .375 in.

The side trimmer was driven by a 60/75 hp, 300/1200

Figure 31 — Oscillograph records typical of those taken on the side trimmer of Figure 29.



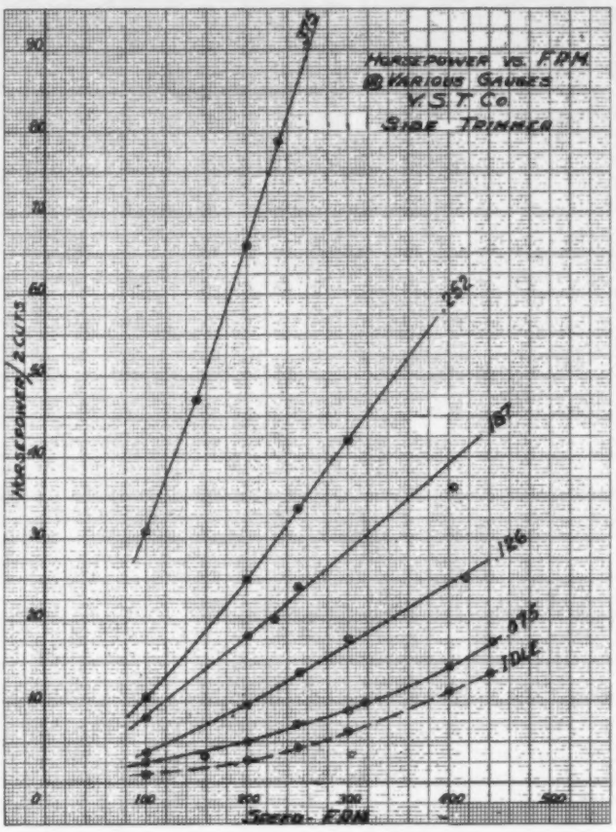


Figure 32 — Curves giving test results of horsepower vs strip speed for heavier gauges in side trimmer. (above)

Figure 33 — Comparison of results obtained from plant test and from shop test on side trimmers. (top right)

Figure 34 — Another comparison of results from plant test and shop test on side trimmers. (bottom right)

rpm, 230 volt, shunt wound d-c motor, and all speed changes were obtained by shunt field rheostat. Readings were made at approximately 320, 600, 800, 1000 and 1400 rpm of the motor, giving linear speeds of 95, 180, 240, 300 and 415 fpm. Here again we obtained a portable oscillograph and set up approximately the same metering equipment as described for the test in the shop. Typical oscillograph records are shown in Figure 31.

The results of this test at Youngstown Sheet and Tube Company are shown in the curves of Figure 32, which again show the same characteristic shape as all the other curves that have been presented.

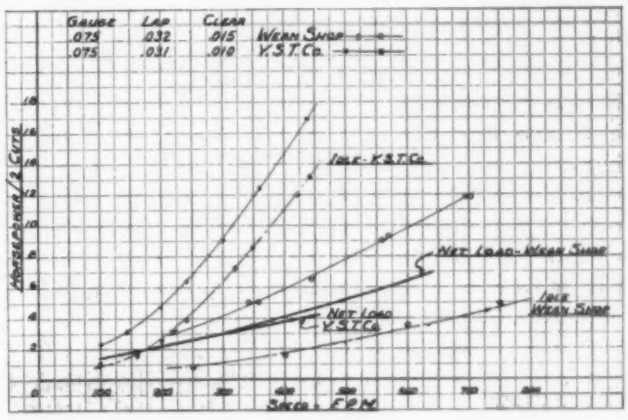
Since two of the thicknesses cut on this large machine at Youngstown Sheet and Tube Company were the same as the thicknesses cut on the smaller machine in the shop, we were very much interested in noting how the net power would compare on the two machines. Figure 33 shows the tests at Youngstown Sheet and Tube Company and in the shop compared when cutting .075 in. thick material. As can be seen, the knife clearance was approximately the same for both machines, although the horizontal clearance was slightly less at Youngstown Sheet and Tube.

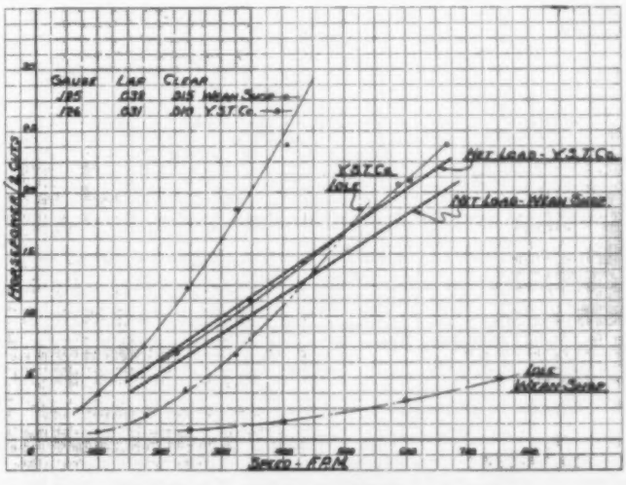
Although the gross power was widely different for the two machines, the idle power also being widely different brings the net power lines almost on top of one another, as can be seen by the heavy lines on the curve sheet. This tends to substantiate the previous statement that the net cutting power would be independent of knife diameter.

It is also interesting to note Figure 34, where the same results have been plotted for .125 in. material. Here the two lines run somewhat farther apart than for the thinner material, but the percentage difference is quite low and can at least partially be explained by the slightly heavier material and slightly less horizontal clearance at Youngstown Sheet and Tube test.

An interesting series of tests was carried out in connection with the power tests made in the shop (as illustrated in Figure 28); .167 in. thick material was cut with four different knife settings and power tests taken. The results can be seen from the three distinct curves in Figure 35. Curves for the third and fourth settings lie pretty much on top of one another, and both settings are incorrect to give the best results. It can be seen from these curves that as the horizontal clearance between the knives is decreased the power tends to increase. Also as the over-lap of the knives increases the power tends to increase.

Superimposed on this chart is a portion of two photomicrographs showing the cut edges of material with two other knife settings. This seems to demonstrate fairly





clearly that for the better knife setting the material broke after being sheared about 35 per cent of its thickness, whereas for the knife setting recording the highest power the material seemed to shear through at least 50 per cent of its thickness before breaking. Examining the samples, it appears that the sample sheared with the least power has the best edge with regard to burr and squareness.

Honesty compels us to state that one other such test

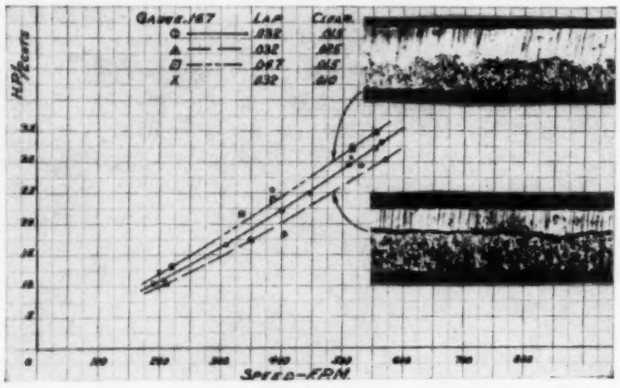
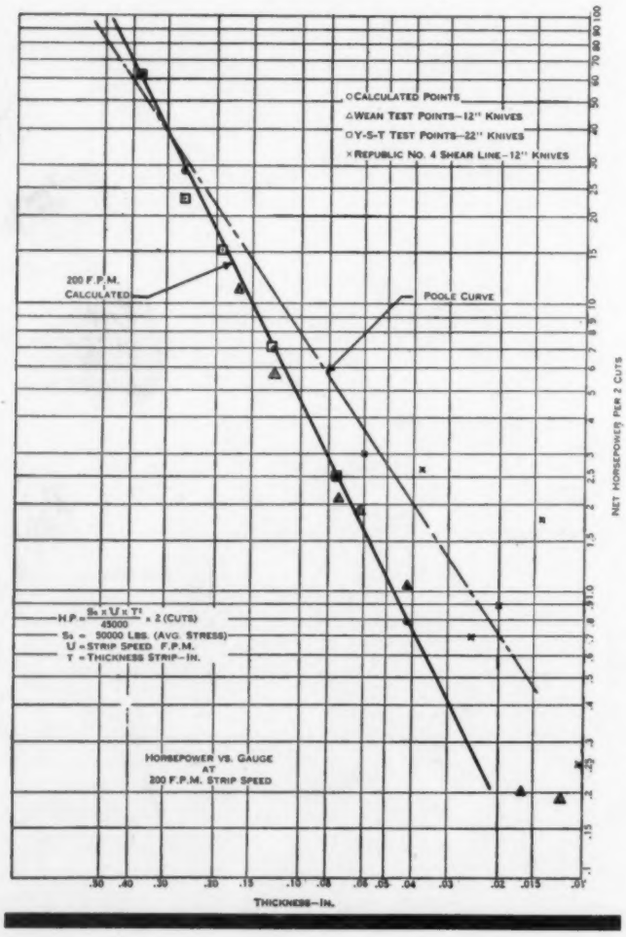


Figure 35 — Chart showing power requirements for different knife settings, as well as photomicrographs showing cut edges of material.

▲

Figure 36 — Horsepower for shearing vs gauge of material. Solid line is calculated from formula. Points plotted are test data.


○ CALCULATED POINTS
△ WEAN TEST POINTS—12" KNIVES
□ Y-S-T TEST POINTS—22" KNIVES
× REPUBLIC NO. 4 SHEAR LINE—12" KNIVES
200 F.P.M. CALCULATED
POOLE CURVE
H.P. = Sₛ × U × T / 45000 × 2 (CUTS)
Sₛ = 50000 LBS. (AVG. STRESS)
U = STRIP SPEED F.P.M.
T = THICKNESS STRIP—IN.
HORSEPOWER VS. GAUGE AT 200 F.P.M. STRIP SPEED
NET HORSEPOWER PER 2 CUTS
THICKNESS—IN.

was made on .042 in. thick material with two knife settings, and for some reason the power was less for the closer clearance, the over-lap being the same in both cases. This test can not be taken as being necessarily correct because the first run was made twenty-four hours before the second one, and several hundred pieces had been cut between the two tests, thus some condition in the machine may have changed to give this unexpected result.

However, there is another possible explanation. The closer knife setting was exactly 20 per cent of the material thickness, which as will be shown later we recommend as a perfect horizontal clearance. The larger knife setting was approximately 35 per cent of material thickness and was larger than we would normally recommend, thus it seems quite possible that power may increase both sides of some ideal knife setting. Not enough tests were run on the same thickness of material with different knife settings to allow us to definitely prove this theory.

To sum up all of the data that has been discussed regarding power for rotary shearing we plotted a theoretical curve from the data shown in Figure 21 showing horsepower at a definite speed in fpm against thickness of strip, and then laid in points from all of the previously described tests to see how they agreed with the theory.

It will be remembered when Mr. Poole had concluded his tests on rotary shearing that he plotted a similar curve and decided that a straight line plotted on logarithmic paper would best represent his results. There has been considerable skepticism among engineers regarding the accuracy of this conclusion. However, it is evident that using the theoretical data given in Figure 21 we will also obtain a straight line upon logarithmic paper, although of a different slope than Mr. Poole's line. Figure 36 illustrates:

1. A line plotted from the theoretical data taken from Figure 21.
2. Mr. Poole's line.
3. The various points obtained from the tests we have described.

It can be seen that for the heavier material, our test data agrees remarkably well with the theoretical line. For the thinner material and smaller horsepower, the correspondence is not so great, and much of our test data agrees more closely with Mr. Poole's line.

Analyzing these results, we are inclined to believe that the theoretical data taken from Figure 21 is very well proven, but that for the small horsepowers involved in shearing the very light material, the theoretical line cannot be taken without a factor of safety for specifying motor horsepower requirements.

When it is realized that many of the points falling off of the theoretical line represent fractions of a horsepower, and that the friction load of the machine is several times the work required to do the cutting, it can be seen that inaccuracies are sure to occur, and that a considerable factor of safety will represent a very small expenditure for motors.

As can be seen, the points lying farthest off of the theoretical line are the points obtained from one of the tests at Republic, where we mentioned previously thin material gave unusually high horsepower readings.

It also should be noted that the logarithmic paper on

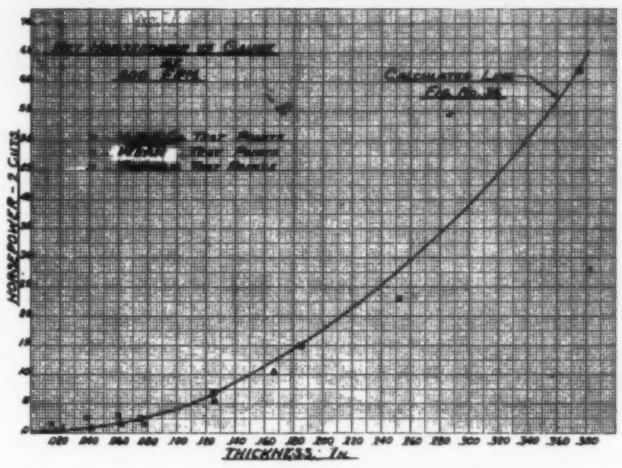


Figure 37 — Observed horsepower plotted with calculated curve on standard cross-section paper.

Figure 38 — Curves of horsepower for shearing vs gauge at various speeds, drawn entirely from experimental data.

which this data is plotted gives a distorted view of these discrepancies. To show this, we have plotted identically the same data on standard cross-section paper shown in Figure 37. As can be seen, even the points which appear to fall at an unexplainable distance from the theoretical line on the logarithmic paper appear to be almost on the line when plotted on standard cross-section paper.

It should be pointed out that all of the data of this figure show net horsepower, that is gross horsepower minus the friction load of the machine. Naturally the theoretical line can only show this and in order to make the test points agree with the theoretical, we in each case subtracted friction load. Therefore in choosing a motor for any side trimmer, it will be necessary to use the data given on this curve and add the supposedly known friction load of the machine. All of the points shown in this curve are for 200 fpm lineal speed of strip. This particular speed was taken because there were tests at this speed on all of the machines we tested, and also because Mr. Poole's curve was drawn at this same speed, and thus allowed an easy method of comparing our results with his.

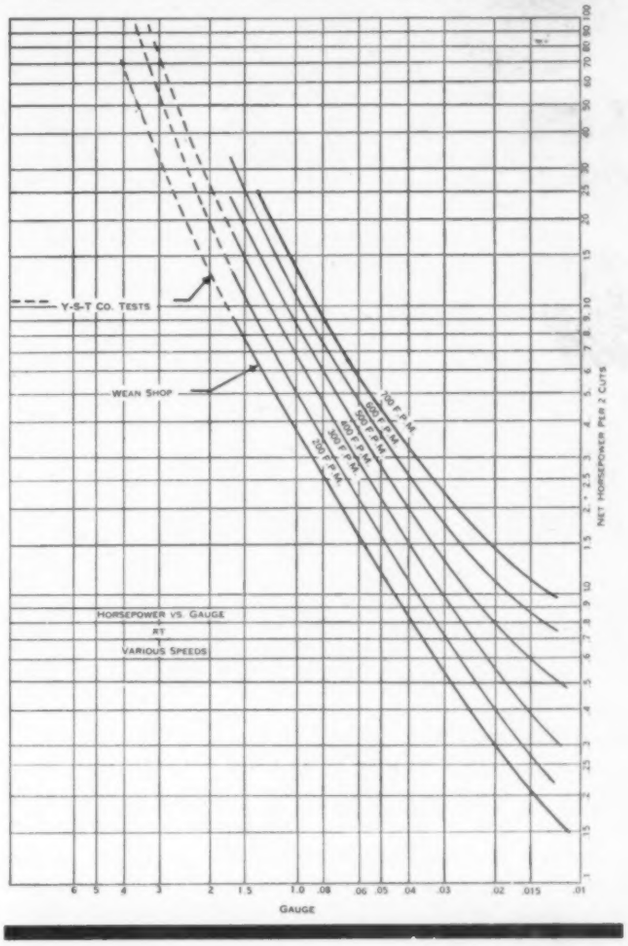
Figure 38 is plotted to the same coordinates as Figure 36, but entirely from experimental data. We have drawn lines showing net horsepower for various thicknesses of steel at five definite speeds.

OPERATING DATA

The concluding portion of this paper will deal with operating suggestions with regard to rotary shearing, side trimming and slitting. Due to lack of space and also due to the fact that the procedure for shearing with straight knives is much more generally understood, our operating practice notes will deal with rotary knives only.

Operators generally classify slitting or side trimming equipment into two broad classes known as "pull through" or "power."

A slitting unit is called a "pull through" type when no power is applied to the knives except through the strip. The power to the strip in such cases almost invariably comes from a reel on which the material is being wound. Often on pull through units some type of power is applied to the knives for a sufficient length of time to feed the end of the material from the knives up to the reel. This may vary from a hand crank to a separate motor and reducer drive which can be disconnected by means of a clutch, or which is provided with an over-running clutch. Various other modifications, including a chain drive from the reel motor, can also be used.



A "power" slitting unit is one in which a motor is applied to the rotary knives to provide more or less power while the material is being cut. Obviously this is a much more flexible unit, and most of the newer slitting lines have been built so they can be used in this way.

If desired, the motor can put only enough power in to over-come the frictional load of the machine, thus allowing the pull of the material to do all the actual slitting. On the other hand, the slitter motor can do all of the work and throw a loop in the material between the slitter and the reel. Obviously if this is the case, some type of tension device must be provided in front of the reel to allow winding a tight coil.

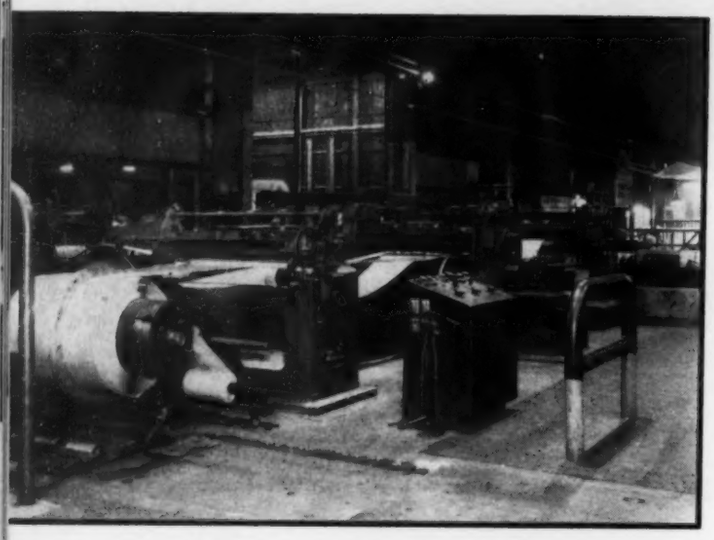
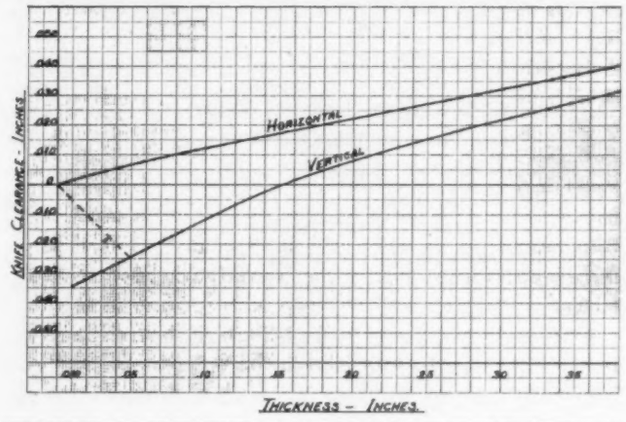


Figure 39 — View of end of slitting line operated with loops after the slitter. Considerable variation of the loops may be noted. ↑

Figure 40 — Diagram showing knife clearance settings for various gauges as used in several plants. →



One of the difficulties encountered with "pull" slitting is the uneven tension obtained on the reel on different strands, due to the difference in build-up, which is caused (1) by variation in gauge across the width of the strip; (2) by buckles or waves in the strip, or (3) by varying qualities of cuts on different strips.

Obviously this becomes more serious the wider the material. The tendency at present is to slit wider and wider material to obtain high production with its attendant low-cost product from wide continuous strip mills.

As wider material is slit, it may be possible that full power slitting must be used and a loop thrown between the slitter and reel. In this manner, constant tension can be maintained on all strands by providing a tension device in front of the reel and allowing the loops to vary as they will due to the variations mentioned. Some few slitting lines have actually been run in this manner with a very remarkable variance between the different loops by the time the end of the coil is reached.

Figure 39 shows a unit being operated with loops after the slitter. Here, only two strands are being cut, and theoretically there should be no variation in length between them. However, it can be seen that one has almost no loop, whereas the other sags about two feet from horizontal, even though very few wraps have been wound on the reel.

Variation in tension not only results in uneven coils, which may not be acceptable to the customer, but also may result in poor slitting on some coils due to the fact that a few strands are putting practically all of the power into the slitting knives, thus making on one setup some material "pull" slit, and some material "power" slit, even though all of the power actually comes from the reel.

It seems to be the consensus of opinion with all operators that given good equipment, good electric control and an intelligent and expert operator, power slitting can do good work on all gauges, widths and types of material.

From the foregoing, it would seem that we should recommend that all slitters should be the "power" type. However, in studying the question further, it is easy to see that the "pull through" type is both cheaper in first cost, and requires less expert operation and electrical maintenance. For instance, if a "power" slitting unit is not properly synchronized as to speed, a worse burr will result than obtained from the crudest "pull" unit.

"Pull through" units in their simpler form can be built with an a-c motor on the reel, and the only electrical operation under the control of the operator is to start and stop the motor.

Obviously such a line does not give constant lineal speed of material, because the material will go faster as the diameter of the reel builds up, and in general we can admit that it is a very crude line. However, if satisfactory slitting can be obtained, it may be preferable to a more elaborate line, and it appears that on certain gauges and types of material satisfactory results can be obtained.

It is also maintained by at least some men familiar with slitting that knife life is considerably longer on the pull through type of machines.

An interesting combination of "pull" and "power" slitting is represented by several modern tin plate side trimming lines. In these lines the material is kept under tension at all times pulling from the coil holder through a set of tension rolls and onto the reel, the reel doing all of the actual pulling. However, instead of letting the trimmer knives idle and being turned by the strip, it has been found by several companies that better results are obtained by driving the knives, sometimes at a speed slightly in excess of a strip speed. In such a line we obviously have "power slitting" in that the knives are driven, but "pull" slitting in that the knives do not move the strip forward.

The side trimmer shown in Figure 5 is in such a line, which explains the absence of guides between the knives; these being unnecessary because the strip is under tension and is thereby held flat by passing over the billy rolls which can be seen adjacent to the side trimmer.

Considerable variation in opinion exists as to what types should be pulled and what types should be slit under power. A consensus of opinion of one group of operators is as follows:

1. All mild steel, .025 in. thick and lighter, should be slit with power on the knives, as it is very difficult to get first class results when pulling. This is especially true on the wider widths.
2. All material .125 in. thick and heavier should be slit with power on the knives. One of the principal reasons for this being that the amount of power required produces a very high tension in the material if it is pulled through.
3. All material over approximately 20 in. wide should be slit with power on the knives.

This leaves material between .025 in. thick and .125 in. thick and less than 20 in. wide in which the pull through slitting is satisfactory. It is obvious that a very large amount of slit material at this time falls within this range. It is also very sure that not all operators will agree with the above figures, and we hope that we will obtain many other opinions which when tabulated may result in some more or less universal good practice being set up.

The setting of the knives for various types of material is another extremely important job. We present the following as a suggested table giving good practice for knife settings. Here again criticisms and suggestions will be very much welcomed. There are two clearances to be considered:

1. The horizontal clearance between faces of knives. For light gauges this should be approximately .002 in. per .010 in. of material thickness. Or in other words, the clearance between knives should be approximately 1/5th the thickness of material. While this amount of clearance would probably shear material even up to $\frac{3}{8}$ in. or $\frac{1}{2}$ in. thick, good right angle edges usually demand a somewhat closer setting. For instance, .040 in. clearance on .375 in. material gave very satisfactory results on some of our tests.
2. The other clearance to be considered is the vertical clearance, which can be either positive or negative; that is the knives may actually over-lap each other, or may not quite meet each other.

We have prepared a diagram, Figure 40, showing vertical clearances in actual use at several steel plants. This shows that the knives are over-lapped for materials less than approximately .130 in. in thickness and are separated for materials over this thickness. Opinions seem to be fairly well agreed as to the amount of vertical clearance for material heavier than .050 in. thick. For material thinner than this, the usual knife settings are shown by the solid line on the diagram, which gives an over-lap of approximately .030 in. for .010 in. material. However, it is the very strong opinion of one group of experienced slitter men that better results will be obtained by using the clearances represented by the dotted lines on the diagram. The dotted lines are based upon an over-lap of one-half the thickness of material for material up to .050 in. thick. We have also shown on this same diagram the recommended horizontal clearance as discussed previously.

Our tests indicate that power increased as the clearance, both vertical and horizontal, became less, and, therefore, good practice would demand that the clearance be the maximum possible consistent with quality shearing.

It is interesting to note that experience shows that larger horizontal clearance can be used when multiple slitting than can be used when side trimming, this seemingly being due to the fact that the unsupported scrap being cut from side-trimmed material tends to make satisfactory cutting impossible without a rather small horizontal clearance between the knives.

We were also interested to find out that, at least approximately, the clearances given in the chart must

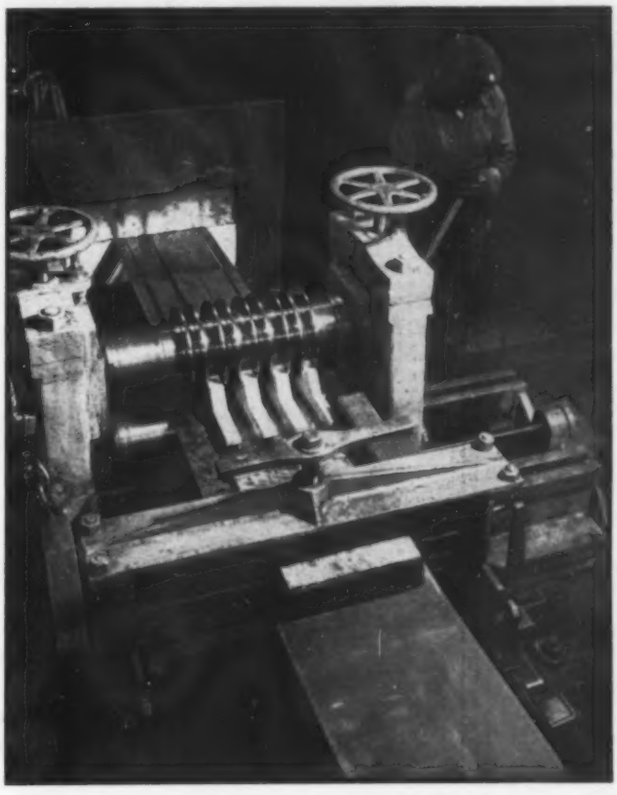


Figure 41 — View of slitter showing type of guides often used.

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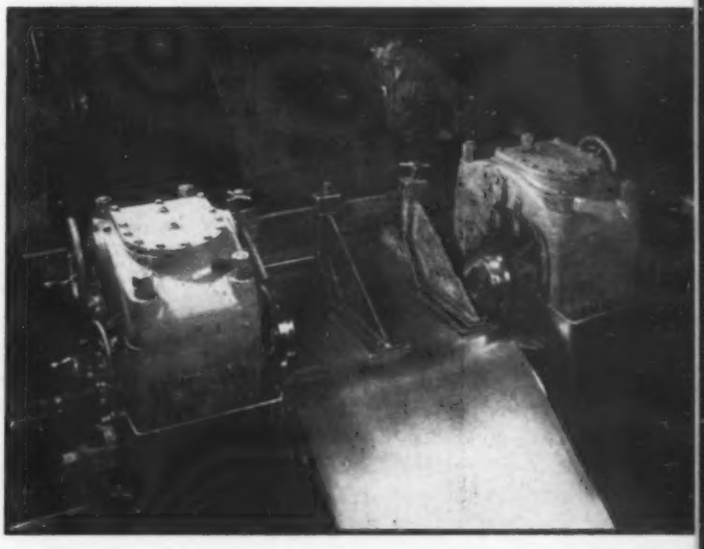
Figure 42 — View showing type of guide often used when side trimming only.



be used to obtain severing of the material. In one of our tests in the shop, the knives were set by engineers and shop men to what they thought was a reasonable figure. The first several pieces put through the machine did not have the scrap severed from the main body of the strip. The knives simply put a nick in the strip. A change in setting allowed about a 95 per cent cut, but here and there the material still remained joined. After contacting a steel mill and talking to practical slitting operators the knives were set approximately as shown and very excellent results obtained without further change to machine, steel or method of feeding.

Another very important feature in connection with trimming or slitting is the type of guides used to hold the material flat between the knives. This guiding largely determines the width tolerance of the material. In slitting material 5 in. and under in width, after-slitting tolerances of plus or minus .005 in. are readily obtained, while tolerances of .002 in. can be obtained when all possible precautions are taken. Figure 41 shows the type of guides often used in slitting. This picture shows guides between knives only on alternate strips. Similar blocks will be used underneath the strip, also on alternate strips, staggered with the blocks on top. The very best practice would use such blocks both top and bottom on all strips, i.e., between all knives, both top and bottom. Obviously, when blocks are used on all strips, two different width blocks must be used, as can be easily seen from the picture.

These guides must be tight on the strip, but have sufficient distance between the top and bottom guides to allow for the thickness of the strip to pass between them.

Having these blocks loose often results in "dished" strip, and many customer-complaints originate from this defect.

When strips are under 2 in. in width, the blocks are not nearly so necessary and fewer can be used even for the most accurate shearing.

Figure 42 shows a simpler type of guide often used where material is side trimmed only.

Another important item in connection with all trimming and slitting is the lubrication of the knives. It would seem from discussing this matter with various operators that very little thought has been given to the proper lubricating medium. Red engine oil is a common lubricant; also various cutting oils and soap oils — actual hard soap has been used in at least one instance. It is possible that some very interesting data could be obtained regarding power requirements and knife life with various lubricants.

One of the most important factors in order to obtain good slitting is not within the control of the slitting line, builder or operator; that is a good flat strip.

In connection with the discussion on pull slitting, mention was made of some of the troubles encountered due to variation in gauge across the width, waves, buckles, etc. Too much emphasis cannot be laid upon the necessity of excellent practice in both hot and cold strip mills when the strip being rolled is to be slit in narrower widths.

Another important feature is the type of mechanism for holding the wide coil in front of the slitter. Most old lines use a very simple type of coil box where the coil rests on gravity rollers. It is quite difficult to obtain good results with such a device due in a great measure to the uneven pull exerted by the coil sitting on its cradle rolls. Both cone and overhung expanding mandrel type coil holders have proved very satisfactory, with the expanded mandrel type being preferred even for very wide widths. In previous years, designs have not been available for using this coil holder for wide heavy coils. However, this difficulty has been largely eliminated, and the overhung coil holder with its advantage in not injuring the inside wraps, tightly gripping the coil on the inside, providing back tension, and other advantages are giving it a strong preference over cone coil holders.

Figure 43 shows the use of an overhung coil holder and illustrates very well how coils are put onto the expanding head. It is important to note that they can just as easily be removed by the same mechanism and discharged to a point away from the feeding ramp without the use of a crane or tractor.

Ease of handling coils to and from one shearing line with such a coil holder has resulted in an actual increase in average production of six tons per 8-hour turn, over and above an identical line using a cone type coil holder.

Proper packing of the arbor is an extremely important phase of satisfactory multiple slitting. As has been mentioned previously, most multiple slitting is done on packed arbors, but various methods of packing are used at different plants. Figure 44 shows the most usual type of packed arbors. Here the knives have a bore accurately machined to fit the diameter of the arbor, and spacers having the same bore, but a considerably smaller diameter than the knives, are placed between the knives to properly position them for making the cut desired.

The longer of these spacers are usually hardened steel, more or less the same composition as shear knives. Steel spacers have been made as thin as $\frac{1}{64}$ in., but in general hardened steel spacers are not used less than $\frac{1}{16}$ in. Steel spacers thinner than this are usually mild steel, due to the extreme difficulty in keeping shape as they are hardened. It is also a common practice in many plants to use hard red fibre for spacers less than $\frac{1}{16}$ in. in thickness. Below $\frac{1}{64}$ in. paper is commonly used. Paper of various thicknesses is usually kept on hand down to perhaps .003 in. One of the advantages of fibre and paper is that they can be cut, and by loosening the nuts which hold the knives and spacers solid on the arbor can be inserted without removing any of the units already packed on the arbor.

At some points, a similar method of packing is used, except that two diameter spacers are used, and between alternate sets of knives spacers full diameter of the knife are inserted. Of course, it would be possible to use extra knives instead of large diameter spacers with this method of packing.

Obviously when spacers the full diameter of the knives are used, wooden guides cannot be used between all of the knives. As can be seen from the figure, it would be possible to use both wooden guides, as can be seen between half of the knives, and large diameter spacers between the other half on the particular setup shown. If wider strands were being slit, either this method of packing or additional wooden blocks would

be desirable, and perhaps necessary, to give accurate slitting.

An important fact to remember in satisfactorily packing an arbor is to use as long a spacer as possible so as to use as few as possible. A small amount of dirt on the surface of any spacers can cause a great deal of trouble due to knife wobble, and therefore poor cutting.

Best practice seems to indicate that the distance between the cutting edges of the female knives should be set at exactly the strip width desired. This means that the distance between the cutting edges of the male knives must then be this distance minus two times the proper horizontal knife clearance.

In this connection, something should be mentioned regarding knife thickness. Obviously when very narrow material is being cut the knives must be less than one-half the strip width, thus requiring very thin knives on some material. On the other hand, thicker knives must be used when heavy gauge material is being cut to prevent springing of the knives. It can be seen that when very narrow heavy gauge material is to be slit, the method of packing using full diameter spacers between alternate knives presents an advantage in connection with springing knives.

The use of pinch rolls has been discussed pro and con for many years, and it has been held by some that at least on heavy gauge material, pinch rolls were essential for entering the strip into the knives and keeping it running at knife speed. No pinch rolls were used on any of the machines employed in our later tests, and all gauges entered the knives and sheared without the slightest hesitation. Even the heaviest material, which was about 1/60 of knife diameter, did not seem to slip on the knives in the slightest.

A very important consideration in connection with good operation of a trimming or slitting line is the amount of side scrap necessary. It is a natural desire on the part of the slitter operator to have as much side scrap as possible. This makes accurate guiding less necessary and insures good edges with a minimum of setup and operating trouble. It is obvious the larger the side scrap, the higher the total cost of the operation, due to the variation between charged weight and finished weight. A minimum of $\frac{3}{32}$ in. of scrap on each side of the material is considered practical by some operators. This would probably not be enough for material over about $\frac{1}{8}$ in. thick, and would not be practical for any gauge unless knife settings were very accurate and guiding was practically perfect.

The problem of shear burr on the finished steel strip or plate is one of the most troublesome encountered in connection with shearing. There have been many attempts at solution, but none appears to be perfect. For light gauge material such as tin plate, the burr can usually be knocked down by hardened pinch rolls or similar device, such as a ball bearing race running on the edge of the strip as it passes over a billy roller. Burrs on thin gauge strip have also sometimes been knocked off by pulling the strip over the sharp edge of a hardened steel knife such as an old rotary shear knife.

On heavier gauge slit material, the burr is much less easy to remove. Frequently, it is not removed. In slitting, every attempt is made to keep the burr at a minimum, and it is allowed to remain on the strip.

Figure 43 — The overhung coil holder with expanding head is advantageous in a slitting line.

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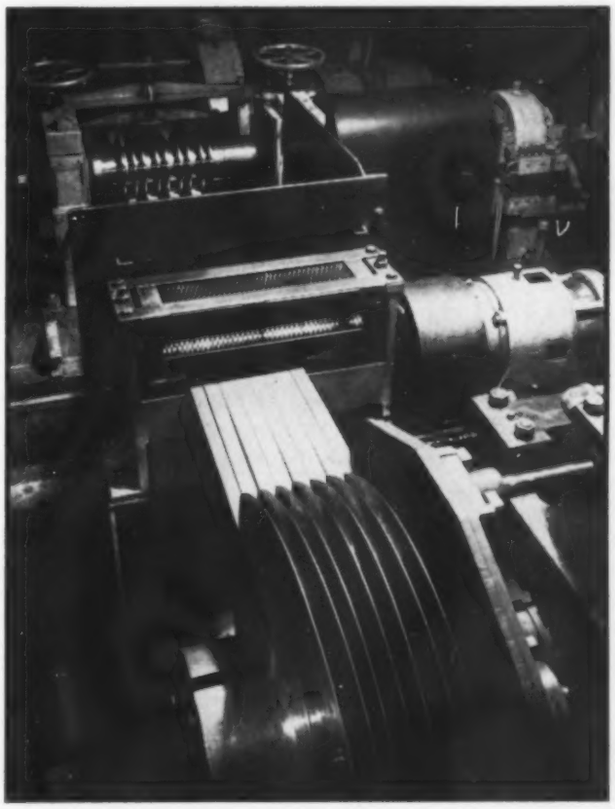
Figure 44 — In packed arbor slitting, the knives have a bore accurately fitting the arbor. Spacers between knives position the knives for making the desired cut.



Often the customer may require that the burr on all strands be in the same direction. This necessitates either re-winding alternate strands that have been formed on one reel, or the installation of two reels in the slitting line, so that alternate strands can be wound under and over.

In many narrow strip mills, material which must be shipped out without the shear burr is side trimmed directly in front of a cold mill, and then passed in

tandem through a cold mill which both tempers the material and knocks down the burr. There is considerable difference of opinion as to exactly where this burr goes and whether this method of eliminating it is entirely satisfactory.

Rolling sheared material in this manner may tend to force the burr into the body of the steel, thus making the strip harder along the edges. Especially in Silicon steel this condition has been observed and has caused difficulties. Of course, this hardness can also be partially caused by the rubbing of the trimming knives against the material as it is being cut.

Another popular method of removing burr is to pull a narrow strip between a series of files — sometimes as many as 36 files being arranged in tandem. This method has the advantage of actually removing the burr, rather than rolling it in or bending it over along side the edge of the strip.

Still another device has been built for relatively narrow heavy strip where the edge is actually rolled to a rounded shape, or at least the corners are rounded off. This method obviously cannot be used for wide material or thin material.

In general, it would seem safe to say that the perfect solution to burr removal has not yet been found. Obviously the best solution would be the proper setting of all knives so that little or no burr is made as the material is sheared. Although it is impossible to say that all burr can be eliminated — by proper design of machinery, proper grinding of knives and most of all proper setting of knives, the burr can be held at a minimum, and the difficulty of eliminating it largely minimized.

We will very briefly mention several types of slitters which have been sometimes used in the past.

At one time there was built what is known as a "floating top arbor" slitter, where the top arbor was held in alignment only by its knives overlapping the bottom arbor knives. At one time, it was thought such an arrangement would give very satisfactory results, but it is now thought this is practically obsolete.

Various trimmers and slitters have been built with only one arbor driven, and it appears this is a poorer device than even pull slitting, and should never be recommended.

We found on some of our investigations that different diameter knives were being used on a driven side trimmer with knives positively geared together. Obviously this caused considerable slippage and lost power, and is not to be recommended. On a straight pull through unit with knives not geared together, different knife diameters might be entirely satisfactory.

The results of sixteen samples of steel slit on Republic Steel Corporation No. 27 slitting line with various knife settings are as follows:

No. 1 — 3.0 in. x .027 in. slit coil section
Annealed mild steel, temper rolled
Knife overlap = plus .014 in. (correct)
Minimum burr.

No. 2 — 3.0 in. x .027 in. slit coil section
Annealed mild steel, temper rolled
Knife overlap = plus .000 in., minus .000 in. (too little)
Scrap sticking and light burr where scrap broke free.

No. 3 — 3.0 in. x .027 in. slit coil section
Annealed mild steel, temper rolled
Knife overlap = plus .053 in. (too much)
Heavy burr.

No. 4 — 3.0 in. x .125 in. slit bar section
Annealed mild steel, temper rolled
Knife overlap = minus .027 in. (correct)
Minimum burr, edge bevel and depth of break.

No. 5 — 3.0 in. x .125 in. slit bar section
Annealed mild steel, temper rolled
Knife overlap = .022 in. (too little)
Scrap sticking and light burr where scrap broke free.

No. 6 — 3.0 in. x .125 in. slit bar section
Annealed mild steel, temper rolled
Knife overlap = minus .011 in. (too much)
Heavy burr, straight edge and minimum depth of break.

No. 7 — 3.0 in. x .027 in. slit coil section
Annealed mild steel, temper rolled
Clearance between knives = .004 in. (correct)
Minimum burr.

No. 8 — 3.0 in. x .027 in. slit coil section
Annealed mild steel, temper rolled
Clearance between knives = 0 in. (too little)
Heavy burr and dished edges.

No. 9 — 3.0 in. x .027 in. slit coil section
Annealed mild steel, temper rolled
Clearance between knives = .012 inch (too much)
Heavy burr.

No. 10 — 3.0 in. x .125 in. slit bar section
Annealed mild steel, temper rolled
Clearance between knives = .022 in. (correct)
Minimum burr and smooth break.

No. 11 — 3.0 in. x .125 in. slit bar section
Annealed mild steel, temper rolled.
Clearance between knives = .004 in. (too little.)
Heavy burr and minimum depth of break.

No. 12 — 3.0 in. x .125 in. slit bar section
Annealed mild steel, temper rolled
Clearance between knives = .031 in. (too much)
Heavy burr, high degree of edge bevel and depth of break.

No. 13 — 3.0 in. x .027 in. slit coil section
Annealed mild steel, temper rolled
Knife overlap = plus .014 in.
Clearance between knives = .004 in.
Cutting edge of outside knives dulled to throw most of burr on scrap.

No. 14 — 3.0 in. x .027 in. slit coil section
Annealed mild steel, temper rolled
Knife overlap = plus .014 in.
Clearance between knives = .004 in.
Dished edges caused by too much space between backing-up guide and inside knives.

No. 15 — 3.0 in. x .020 in. slit coil section
Annealed mild steel, temper rolled
Knife overlap = plus .010 in.
Clearance between knives = .004 in.
Bad edge condition caused by excessive tension on "pull through" type slitter.

No. 16 — 3.0 in. x .020 in. slit coil section
Annealed mild steel, temper rolled
Knife overlap = plus .010 in.
Clearance between knives = .004 in.
Good edge condition caused by no tension on "driven" type of slitter.

In conclusion, we will mention a few of the things that are not covered by this paper, or by our experiments, and which would well bear consideration:

We obtained no tests regarding the forces involved in rotary shearing, although we do give you theoretical data, and since the horsepower data were plotted from the theoretical forces and agree very well with test horsepowers, we can feel reasonably certain that the theoretical force data are fairly near correct.

No very extensive tests were taken of peripheral speed of knives versus speed of strip.

No power tests were taken with more than two cuts being made with rotary shears.

Not enough data obtained on power with various knife settings.

No attempt was made to investigate differences in shearing high-carbon and alloy steels rather than mild steel.

No data presented regarding mechanical design of shears.

No data presented regarding makeup of shear lines in strip mills for various purposes.

No practical operating data presented for shearing with straight knives.

Various other factors which no doubt have considerable influence on power forces, accurate shearing, etc., have not been investigated carefully, i.e., imperfection due to worn parts, rubbing of the knives on the strip, magnetism in the knives, blunt edges on knives — and other factors. It is hoped that future papers will deal with some of these subjects.

We wish to express our gratitude and acknowledge our indebtedness to the following companies who have made available to us their facilities and the time of many of their engineering and operating men to obtain the data presented in this paper: Republic Steel Corporation, American Steel and Wire Company, The Youngstown Sheet and Tube Company, Jones and Laughlin Steel Corporation, Sharon Steel Corporation, Bethlehem Steel Corporation, General Electric Company, Clark Controller Company, Reliance Electric and Engineering Company, and The Wean Engineering Company.

APPENDIX

REPORT OF TEST DATA SECURED ON VARIOUS LINES DURING PRODUCTION OPERATION

▲

TESTS CONDUCTED AT THE AMERICAN STEEL AND WIRE COMPANY, CLEVELAND, OHIO

A — SLITTING LINE

Mechanical equipment

Uncoiler, cone type, Cradle rolls and friction brake
Leveler, 9-roll, 6 in. diameter rolls
Slitter, knife diameter, 15½ in., with pinch rolls
Scrap-chopper, 4 knives
Tension reel, empty reel, 20 in. diameter
Maximum coil, 40 in. diameter

Electrical equipment

Uncoiler, no motor, friction brake
Leveler, 1 — 75 hp, 690/1190 rpm, 651-T, d-c
Slitter, 1 — 75 hp, 690/1190 rpm, 651-T, d-c
Scrap-chopper, 1 — 10 hp, 175 rpm, gear motor, a-c
Reel, 1 — 75 hp, 300/1200 rpm, 1050-T, d-c
Variable-voltage motor-generator set consisting of:
1 — 150 kw, 1150 rpm, 250 volt generator
1 — 7½ kw, 1150 rpm, 27 volt booster
1 — 250 hp, 1150 rpm, squirrel cage induction motor

Test No. 1

Material: .75 carbon steel, .085 in. thick, 22¼ in. wide
Number of cuts.....5
Linear speed.....235 fpm

	Rpm	Amp	Volts	Hp (approx)
Leveler	1100-1150	60	255	14.1
Slitter	1050	40	255	9.4
Reel	700 Full Coil	60	255	16.1
			Total hp	39.6

Test No. 2

Material: .75 carbon steel, .085 in. thick, 22¼ in. wide
Number of cuts.....5
Linear Speed.....90 fpm

	Rpm	Amp	Volts	Hp (approx)
Leveler	430	55	100	5.1
Slitter	410	0	100	0.0
Reel	275 Full Coil	50	100	5.8
			Total hp	10.9

Test No. 3

Material: Rustless 12-T-410, .250 in. thick, 24¼ in. wide.
Number of cuts.....3
Linear speed.....62 fpm

	Rpm	Amp	Volts	Hp (approx)
Leveler	296	45	83	4.0
Slitter	282	5	83	.3
Reel	190 Full Coil	65	83	5.8
			Total hp	10.1

Test No. 4

Material: Rustless 17-T-430, .200 in. thick, 24¼ in. wide
Number of cuts.....4
Linear speed.....62 fpm

	Rpm	Amp*	Volts	Hp (approx)
Slitter	282	58	85	5.3
Leveler	296	46	85	4.2
Reel	190 Full Coil	59	85	5.6
			Total hp	15.1

*Average value of 6 coils

Test No. 5

Material: Rustless 17-T-430, .200 in. thick, 24¼ in. wide
Number of cuts.....2 (no side trimming)
Linear speed.....230 fpm

	Rpm	Amp	Volts	Hp (approx)
Leveler	1080	60	255	14.10
Slitter	1030	50	255	11.75
Reel	685 Full Coil	55	255	14.75
Total hp				40.60

Test of machines idling

	Rpm	Amp	Volts	Hp (approx)
Leveler	360	20	120	2.25
Slitter	430	20	120	2.25

Loop from leveler to slitter. Load on slitter does not drop when strip leaves the leveler.

B — SHEARING LINE

Mechanical equipment

Uncoiler, cone type, friction drag
Slitter, 12 in. to 11½ in. knife diameter with pinch rolls
Flying shear, maximum cut 202 in. long, minimum cut 18 in. long
Scrap-baller

Electrical equipment

Uncoiler, no motor
Slitter, 25/30 hp, 450/1500 rpm, d-c
Flying shear,40 hp, 400/1200 rpm, d-c
Scrap-baller, a-c motor

Test No. 1

Material: .062 in. thick, 23½ in. wide
Side trimmer.....2 cuts
Flying shear.....52½ in. lengths, 26 pieces per minute
Linear speed.....150 fpm

	Amp	Volts	Hp (approx)
Slitter	8	230	2.0
Shear	45-55	230	12.5
Total hp			14.5

Test No. 2

Material: .062 in. thick, 23½ in. wide
Side trimmer.....2 cuts
Flying shear.....52½ in. lengths, 44 pieces per minute
Linear speed.....165 fpm

	Amp	Volts	Hp (approx)
Slitter	11	230	2.5
Shear	60-75	230	15.0
Total hp			17.5

Test No. 3

Shear running idle at 170 fpm

	Amp	Volts	Hp (approx)
Shear	45-60*	230	11 to 14

*Maximum amperes occur on the "shear stroke."

C — SLITTER No. 15

Mechanical equipment

Coil box
Slitter, knife diameter 7¾ in.
maximum gauge .250
maximum width 8 in.
Scrap-baller
Reel, core diameter 15½ in.
maximum coil 32½ in. diameter

Electrical equipment

Coil box, no motor
Slitter, 25 hp, 400/1600 rpm
Scrap-baller, driven by slitter motor through slip clutch
Reel, driven by slitter motor through slip clutch

Test No. 1

Material: .08 carbon steel, .137 in. thick, 1½ in. wide
Number of cuts.....6
Linear speed.....165 fpm

	Rpm	Amp	Volts	Hp (approx)
Slitter motor	830	120	230	33.0
Slitter motor idling	860	26	230	6.5

D — SLITTER No. 28

Maximum material: .125 in. thick, 27½ in. wide
Coil size delivered: 20 in. I.D., 42 in. O.D.

Mechanical equipment

Coil box
Slitter, 10½ in. diameter knives (maximum), 9 in. diameter knives used on test
Scrap-baller
Reel, core — 16 in. diameter. Maximum coil 30 in. diameter.

Electrical equipment

Coil box, no motor
Slitter, 75 hp, 500/1500 rpm, d-c
Scrap-baller, driven by slitter motor through slip clutch
Reel, driven by slitter motor through slip clutch

Test No. 1

Material: High silicon steel, .025 in. thick, 27½ in. wide
Number of cuts.....5
Linear speed.....465 fpm

	Rpm	Amp	Volts	Hp (approx)
Slitter	1500	135	230	35
Slitter (idling)	1500	67.5	230	16

E — SLITTER No. 24

Maximum material: 250 in. thick, 26½ in. wide

Mechanical equipment

Coil box
Slitter, maximum knife diameter 10½ in.
Test used knife diameter 9 in.
Scrap-baller
Reel

Electrical equipment

Coil box, no motor
Slitter, 35 hp, 500/1500 rpm, d-c
Scrap-baller, driven by slitter motor through slip clutch
Reel, driven by slitter motor through slip clutch

Test No. 1

Material: S.A.E. 1020, .218 in. thick, 9⅛ in. wide
Number of cuts.....2
Linear speed.....140 fpm

	Rpm	Amp	Volts	Hp (approx)
Slitter	865	110	230	30

Test No. 2

Material: S.A.E. 1020, .105 in. thick, 24¼ in. wide
Number of cuts.....2
Linear speed.....135 fpm

	Rpm	Amp	Volts	Hp (approx)
Slitter	835	52.5	230	13
Slitter (idling)	865	15	230	3

TESTS CONDUCTED AT THE JONES AND LAUGHLIN STEEL CORP. OTIS WORKS, CLEVELAND, OHIO

A — 72 IN. SHEARING LINE

Range of material: .015 to .090 in.

Mechanical equipment

Uncoiler, cone type, friction drag, 2 bank brakes, 3½ in. wide and 32 in. diameter

Side trimmer, knife diameter 10 in., pinch rolls driven by P. I. V. unit
Scrap-chopper, 2 knives, 14 in. diameter
Approach table
Flying shear, 14 rolls, 5 in. diameter
Delivery table

Electrical equipment

Uncoiler, 2 — 7½ hp, 1200 rpm, a-c motors for inching
Side trimmer, 40 hp, 400/1600 rpm, d-c motor
Scrap-chopper, 10 hp, 400/1600 rpm, d-c motor
Flying shear, 50 hp, 400/1600 rpm, d-c motor
Delivery table, 5 hp, 20/80 rpm, d-c gear motor

Test No. 1

Material: Cold rolled steel, low carbon, .092 in. thick, 28½ in. wide
Side trimmer, 2 cuts
Flying shear, Length of cut 57 in., 44 cuts per minute
Linear speed, 200 fpm

	Rpm	Amp	Volts	Hp (approx)
Side trimmer	1280	40	230	10
Scrap-chopper	....	14	230	3.5
Flying shear	1280	45-95*	230	11-25
Delivery table	....	14	230	3.5

*Peak amperes on cut stroke.

B — 42 IN. SLITTING LINE

Mechanical equipment

Uncoiler, cone type with friction drag
Slitter, with pinch rolls driven by P. I. V. unit,
knife diameter 10 in.
Scrap-chopper
Reel, core diameter 20 in.

Electrical equipment

Uncoiler, no motor
Slitter, 25/30 hp, 400/1600 rpm, d-c
Scrap-chopper, 10 hp, 400/1600 rpm, d-c
Reel, 30/40 hp, 400/1600 rpm, d-c

Test No. 1

Material: .036 in. thick, 25 in. wide
Number of cuts.....2
Linear speed.....212 fpm

	Rpm	Amp	Volts	Hp (approx)
Slitter	....	0	245	0
Scrap-chopper	....	10	245	2.5
Reel	1250	28	245	6.0

Test No. 2

Material: .042 in. thick, 25 in. wide
Number of cuts.....2
Linear speed.....162 average

	Rpm	Amp	Volts	Hp (approx)
Slitter	....	0	245	0
Scrap-chopper	....	10	245	2.5
Reel	1250	28	245	6.0

TESTS CONDUCTED AT THE SHARON STEEL CORPORATION SHARON, PENNSYLVANIA

A — SLITTING LINE No. 9

Maximum capacity, .187 in. thick, 4 cuts

Mechanical equipment

Uncoiler, friction drag
Slitter, 10¾ in. knives
Reel, 16 in. diameter core, 35 in. diameter maximum coil
Friction carpet drag between slitter and reel

Electrical equipment

Uncoiler, no motor
Slitter, 50 hp, 400/1200 rpm
Reel, 90 hp, 360/1260 rpm
Variable voltage motor-generator set consisting of:
1 — 100 kw, 250 volt generator, minimum voltage 35 volts
Operator uses 160 volts for "threading".

Test No. 1

Material: .64 carbon steel, .041 in. thick, 14 in. wide
Number of cuts.....4
After the material is threaded up, the slitter motor is disconnected from the line and the line is operated as a pull through slitter. Linear speed increased as diameter of coil increased. Reel loads were as follows:

Fpm	Amp	Volts	Hp (approx)
1025	95	250	24
1275	105	250	27

Fpm	Amp	Volts	Hp (approx)
1025	140	250	37
1275	145	250	39
1500	165	250	45
860	35 (idle)	250	4

Load variation resulted from variation in friction drag.

B — SLITTER No. 3

Mechanical equipment

Uncoiler, friction drag
Slitter, knife diameter, 12 in.
Reel, 16 in. empty core; maximum coil 40 in. diameter
Above equipment operates as a pull through slitter.

Electrical equipment

Uncoiler, no motor
Slitter, 13 hp, 630 rpm, d-c motor with free-wheeling clutch. Motor is only used to feed strip to the reel.
Reel, 60 hp, 300/1200 rpm, d-c motor
In operating the above line, the operator does not slow down the reel motor as the diameter builds up, consequently the linear speed increases during a run.

Test No. 1

Material: Hot strip, pickled and oiled, .103 in. thick, 6½ in. wide
Number of cuts.....2

	Rpm	Fpm	Amps	Volts	Hp (approx)
Reel motor	940	1420	130	230	32
Reel motor	940	Idling	35	230	8

C — SLITTER No. 10

Mechanical equipment

Uncoiler, friction drag
Slitter, 8⅜ in. knife diameter
Friction drag, carpet drag
Reel, 16 in. empty reel diameter

Electrical equipment

Uncoiler, no motor
Slitter, 2 hp motor for feeding only
Reel, 60 hp, 300/1200 rpm, d-c motor

Test No. 1

Material: Galvanite, 4-temper, .08 carbon, .40-.60 manganese .037 in. thick, 5⅝ in. wide
Number of cuts.....3

	Fpm	Rpm	Amp	Volts	Hp (approx)
Reel motor	700	440	60	230	15
Reel motor	1040	660	65	230	16
Reel motor (idling)	....	1250	45	230	11

D — SLITTER No. 4

Mechanical equipment

Uncoiler, friction drag
Slitter, 7⅛ in. knife diameter
Reel, 16 in. empty reel diameter

Electrical equipment

Uncoiler, no motor
Slitter, 50 hp, 400/1600 rpm, d-c motor
Reel, Driven by slitter motor through a slip clutch

Test No. 1

Material: Galvanite, .08 carbon, .40-.60 manganese .042 in. thick, 11½ in. wide
Number of cuts.....6

	Fpm	Amp	Volts	Hp (approx)
Slitter motor	600	70	230	17
Slitter motor	650	90	230	22

TESTS CONDUCTED AT THE YOUNGSTOWN SHEET AND TUBE COMPANY

CAMPBELL WORKS, YOUNGSTOWN, OHIO

A — SLITTING LINE

Mechanical equipment

Uncoiler, friction brake, hydraulically operated
Slitter, knife diameter 16½ in. maximum, 14½ in. minimum, pinch rolls driven through slip clutch
Scrap-chopper
Reel, 23½ in. empty reel diameter, 42 in. maximum coil

Electrical equipment

Uncoiler, no motor
Slitter, 30/40 hp, 300/1200 rpm, d-c motor
Scrap-chopper, driven by slitter motor
Reel, 60/125 hp, 225/900 rpm d-c motor

Test No. 1

Material: Cold rolled strip, .059 in. thick, 38½ in. wide
Number of cuts.....3

	Fpm	Amp	Volts	Hp (approx)
Slitter	400	130	230	32
Reel	400	190	230	46
Total hp				78
Slitter	155	30	230	7
Reel	155	110	230	26
Total hp				33
Slitter	400	80	230	20
Reel	400	220	230	55
Total Hp				75

B — SHEARING LINE

Mechanical equipment

Uncoiler, friction drag
Side trimmer, 16½ in. maximum knife diameter
14½ in. minimum knife diameter
Leveler, 4⅝ in. diameter rolls, 13 rolls
Flying shear, drum type, maximum length cut 240 in., minimum length cut 41 in.

Electrical equipment

Uncoiler, no motor
Slitter, 40/50 hp, 400/1600 rpm, d-c motor
Leveler and flying shear, 60/75 hp, 400/1600 rpm, d-c motor

Test No. 1

Material: Hot rolled steel, 14 gauge, .071 to .079 in. thick, 35 in. wide
Number of cuts.....2 on side trimmer
Length of cuts.....76 in. long
Linear speed.....300 fpm

	Amp	Volts	Hp (approx)
Slitter	60-75	230	16
Leveler and flying shear	190	230	31
Total hp			47

TESTS CONDUCTED AT THE BETHLEHEM STEEL COMPANY LACKAWANNA PLANT BUFFALO, NEW YORK

A — SLITTING LINE

Maximum gauge, .137 in.

Mechanical equipment

Uncoiler, mechanical drag brake
Slitter, 14⅜ in. diameter knife (ground on side), double pinch rolls
Scrap-chopper, 2 knives; 117-234 rpm
Reel, 20 in. diameter empty reel, 40 in. O. D. maximum coil, 51 in. O. D. maximum coil by pull through slitting

Electrical equipment

Uncoiler, no motor
Slitter, 40 hp, 1150/1440 rpm, d-c motor
Scrap-chopper, 10 hp, 850/1700 rpm, d-c motor
Reel, 60 hp, 600/1200 rpm, d-c motor
Variable voltage motor-generator set consisting of:
1 — 75 kw, 720 rpm, 250 volt main generator
1 — 7½ kw, 720 rpm, 320 volt reel booster.
1 — 100 hp, 720 rpm, 25 cycle squirrel cage motor
Excitation from 240 volt d-c shop line
Scrap-chopper motor operates direct from 240 volt d-c shop line.

Test No. 1

Material: Low carbon steel, .034 in. thick, 34 in. wide
Number of cuts.....5

	Fpm	Amp	Volts	Hp (approx)
Slitter	50	35-40	40	1.6
Reel	50	40	40	1.7
Slitter	125	27-30	75	2.3
Reel	125	60	75	4.8
Slitter	200	33-39	130	5.1
Reel	200	50	130	7.0
Slitter	50	20	40	.78
Reel	50	50	40	2.15
Slitter	130	20-30	82	2.15
Reel	130	50	82	4.30
Slitter	200	40	125	5.4
Reel	200	60	125	8.1

Test No. 2

Machinery idle

	Fpm	Amp	Volts	Hp (approx)
Slitter	80	24	60	1.44
	175	27	112	3.25
	260	33	165	5.85
	360	51	165	9.1
Reel	280 (Empty)	20	165	3.58
	184	15	110	1.55
	101	9	60	.50

Test No. 3

	Rpm	Amp	Volts	Hp (approx)
Scrap-chopper (idling)	1675	4.8	230	1.03
Scrap-chopper (loaded)	1675	5.6	230	1.20

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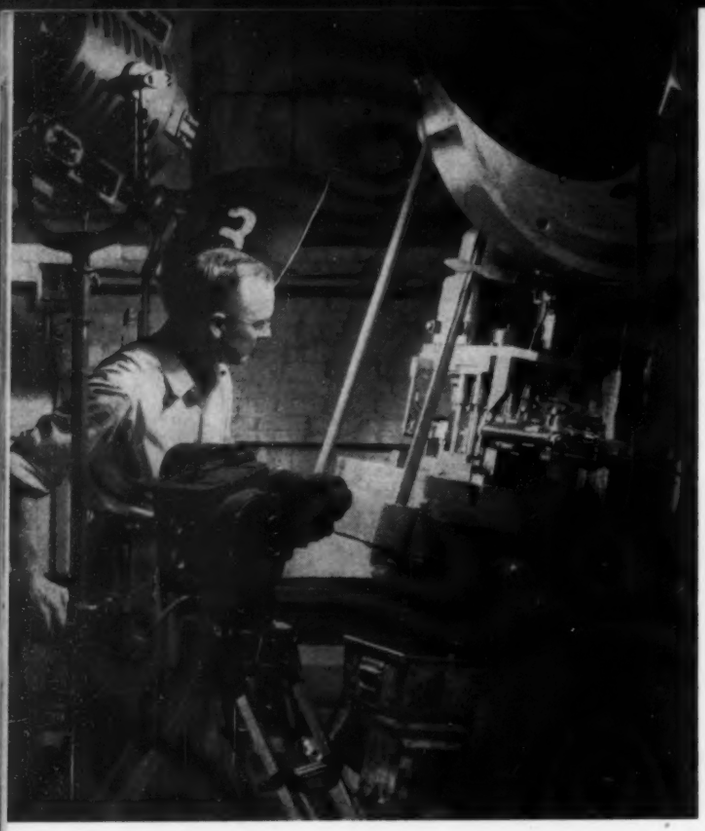

. . . . ultra high speed photography has proven a valuable tool in many fields of industry, slowing rapid motions to a walk . . . . this new medium is available for the investigation of individual problems as desired . . . .

Harnessing TIME AND MOTION FOR

▲ INDUSTRY has been quick to recognize the many possibilities of research in the ultra-high speed camera. Long limited to the 64 and 128 frames a second of older types, which failed to record the higher speeds of modern tools, designers and research engineers are learning unbelievable lessons as revealed by the 3200 frames a second speed of this new camera. Theoretical assumptions are being verified or discredited with uncompromising factual data. Motion is undergoing intelligent analysis and scrutiny, much as was made possible in other lines of research when X-ray, high power microscopes and other scientific research instruments became available.

With this new instrument of research and operational trouble-shooting, mile-a-minute speeds show on the screen in slow-motion at 26 feet a minute; 3000 rpm become 15, with all the motion effects of the higher speeds retained. Motion is reduced to 1/200th of actual. One hundred feet of standard 16 mm film pass through the camera in 1¼ seconds, yet take 4½ minutes to view on the screen.

Presented before A. I. S. E. Cleveland-Youngstown District Meeting, March 20-21, 1944

The value of high speed photography is not restricted to any one science or field of research. It is not even restricted to so-called major problems. The medium provides accurate scientific data for the serious research worker, but it also is helpful in solving production problems that are occurring every day in almost every shop and factory. Whenever ultra-slow motion pictures are used, not only is the original problem answered, but in many cases other factors are indicated or proven which were never suspected or considered at the time. Somewhere on the screen, adjacent to the principal points of study, something else is taking place, and its indication in slow motion proves to be of real value in itself.

In the application of the ultra-high speed camera to scientific research, the correct method of interpreting the film is of the utmost importance. High speed pictures can be studied under standard projection speed as a slow motion picture in any standard 16 mm projector. Where original photography has been executed at 3200 frames per second, these pictures may be viewed at a speed 200 times slower than normal, when projected at 16 fps. Slower taking speeds reduce the proportion, but even at the slowest speed possible with this equipment — 900 fps — extreme slow motion is evident on

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INDUSTRIAL RESEARCH

projection and is most helpful in analytical work. These same pictures may be studied frame by frame with a suitable magnifying glass or low power microscope. In work with glass fracture, explosions, bullet impact, and other subjects of extreme high original speeds, this method of study is perhaps the best for providing the required data. Projecting films in reverse provides another means of study, in which many originating movements and actions can be traced. In forward projection, phenomena of this type are often missed entirely.

The technique of camera operation involves so many conditions not encountered in usual photographic work, either motion or still, that personal experience by the operator is of prime importance. Then, too, each subject becomes a study within itself calling for not only photographic ability, but technical ingenuity as well. Our organization has taken hundreds of thousands of feet of ultra speed film under widely varying conditions and has the experience and equipment necessary to meet almost any requirement.

Getting sufficient light onto the subject is the source of greatest concern. Even when taken out-of-doors in brilliant sunlight, additional spot and flood lights are required. In some instances it is necessary to photograph action in silhouette, the lights being behind a moving subject and shining directly into the camera.

When a precise point of intermittent or impact action must be photographed at this high speed, synchronization between the subject and film exposure becomes an all-important factor. Allowance for motor acceleration must be carefully calculated in reference to the moment of action wanted, remembering that, running at 3200 fps, only one and a quarter seconds are available to catch the action.

A special synchronizing mechanism has been developed which largely eliminates the fallability of the human element. Without this mechanism many rolls of film could be used without once catching the desired action. This is particularly true of glass fracture, where the instance of primary fracture has frequently taken place between exposures — even when taken at 3200 frames a second.

Taking pictures of action within closed areas, such as valve action, fuel injection and explosions within compression cylinders, presents a problem of introducing not only transparent parts for the camera, but means of intense interior lighting as well. Before the preparation of special equipment for such studies is started, the research department would do well to consult the photographer. Such a procedure takes advantage of past experiences and reduces the element of chance or possible failure in obtaining the expected result.

Where the ordinary motion picture camera has a minimum objective field of one and a quarter by one inch, the ultra-high speed camera can be focused to a minimum field one-quarter inch square. This permits concentration upon very minute subjects of specific importance. When shown on the screen, the action represents sub-microscopic enlargement of many diameters.

Many cases require accurate measurements of time and space. While provision can be made within the camera for a clocking system capable of recording extremely small intervals of time on the edge of the film, the cost of installation is almost prohibitive, and the system is both bulky and unwieldly. It is possible, however, to provide an accurate time record on the film by inserting in the picture field a stroboscopic light source of known frequency. From the photographic image of this series of light flashes, exact time measurement may be made even to the small interval between two consecutive frames. The image of the flashes may be positioned in the frame at will, and do not interfere in any way with the subject under study.

In measuring space, each project requires the application of a specific method. None are especially difficult to apply and all provide the research worker with adequate and exact figures from which he may make precise readings and prepare accurate charts and graphs. Some cases require the calibration of moving parts against a stationary scale introduced for the purpose. In most cases, however, it is only necessary to insert a suitable scale in the field of photography and in the plane of the subject. Completely detached from all moving parts, it has no effect on them at all, and does not introduce any errors. Upon projection to an enlarged picture, using a sheet of paper as a screen, the scaled divisions may be ruled off the paper in both vertical and horizontal lines. Projected action of the subject upon this screen can be readily calibrated

against the graph providing all the measurements which may be desired.

Pictures which must show what takes place in the center of a machine, and at the same time include something else going on at either side or at a remote part of the machine, really tax the ingenuity of the operator. Skillful use of mirrors, prisms, relays and electronic indicators all help and usually provide the desired data accurately integrated into a single frame. Studies of this type naturally require much time in preparation, and an entire day can be spent in getting everything ready for one or two shots that take only a few seconds to make.

Occasionally it is desirable to produce ultra high speed photography in color. This is not especially difficult where the subject itself is sufficiently self-luminous. Kodachrome is very slow in its emulsion speed and the light emitted by a subject must of necessity be very intense. The electric arc is one of these and provides excellent studies in natural color. Where a subject is not self-luminous, it is necessary to provide an immense amount of incandescent light of correct spectral balance to assure satisfactory register on the film. Providing such an amount of light requires the construction of a complex piece of apparatus capable of flashing 150 flash bulbs in rapid succession. Operational cost of this procedure is very high and is recommended only when color is of paramount importance.

In addition to the field of pure research, the following are two highly important uses for ultra-speed photography which some manufacturers have been quick to appreciate and apply:

1. The educational advantages to be attained by incorporating ultra speed with normal speed photography in visual-training films. The operation of high speed tools and the intricacies of peculiar fabrication techniques can be more readily explained and comprehended when brought down to ultra slow-motion studies.
2. In sales promotion and institutional films, where the selling points of fast-operating features may be brought down to comprehensible speeds.

The applications of high speed photography to the study of motion and motion-effects are as limitless as the applications and uses of motion itself.

An accounting of results obtained through the use of ultra speed photography would be of tremendous interest but, like all phases of research, both in war and peace, secrecy is paramount. Until such time as those for whom films were made see fit to publicize the results, they must remain concealed. However, the circumstances surrounding those problems contain more than a little interest and can direct thought to further applications.

Perhaps the outstanding study in the history of ultra high speed photography was one made some time ago when the equipment was in its early stages of development. The problem concerned the question of the relation between the position of a locomotive drive wheel and the rail at high speeds. The camera was mounted on a specially constructed frame beside the wheel. Necessary lights were also attached to the frame to supply the required amount of illumination. Power was provided by a portable generator installed in one of the cars behind the locomotive. Test runs were made just west of Chicago at speeds up to 70 miles per hour, and the resulting pictures clearly showed that at every revolution of the drive wheel it was jumping on the track the amazing and dangerous distance of one and a half inches. It was evident that certain forces were acting on the wheel that were not known to be present. This discovery and its consequent rectification permit us to recline in our berths today with a complete sense of security.

One of the most comprehensive series of studies made with the high speed medium was in the field of construction and design of machine tools. The high speed camera has aided greatly in determining a number of important factors of tool production. It has for instance:

1. Determined maximum working speeds to which a machine tool can work without erratic operation.
2. Indicated the exact point of danger in material distortion.
3. Shown the angle of distortion of metal on the head of a tool.
4. Indicated the depression and consequent deflection of cutting tools as they build up power to make a cut.
5. Shown the direct relationship between the speed of a tool and its tendency to compress and deflect.
6. Contributed much to the study of distortion due to excessive heat in high speed operation.
7. Provided a chart from which a determination could be made of the maximum speeds possible with minimum regrinding of the tools in use.
8. Definitely indicated the cause of chatter through the study of arbor "wind-up," heat, deflection, irregular feeding, etc.
9. Ascertained the most effective rake and clearance angle necessary to produce a maximum cut at maximum speed.
10. Determined a means of control of the abrasive action or cratering of tools at their face.

All in all, the high speed camera has saved the tool engineer considerable time in research and study and has helped materially in creating tools of greater efficiency and greater potential speed so vital to our all-out industry today.

Another application of the high speed camera was one in which a manufacturer producing machine gun clips was confronted with frequent breakdown in high speed punch press operation. Erratic feed of raw material was suspected, and after all moving parts had been painted with reference lines, the stock was calibrated in quarter inches and fed in before the running camera. At normal press speed of 85 strokes a minute it was impossible to observe accurately with the human eye what was taking place within the machine. Pictures taken at 1000 frames a second slowed down the action to such a degree that it was at once possible to study every movement, vibration and condition in the entire mechanical process. The pictures, projected at normal speed of sixteen frames a second, quickly indicated the source and cause of trouble. Suspicions of erratic feed were confirmed. The cause, an incorrectly designed cam, resulted in radical engineering changes which completely eliminated the trouble. It is interesting to note in this case that the client was spending over a thousand dollars a month for die repairs to say nothing of the

time lost in press shut downs. The simple research facilities of the high speed camera indicated the trouble, suggested its method of rectification, and saved him a considerable amount of time and money.

In still another application, a number of studies were made in black and white to indicate the pattern of turbulence of oil burner flames within a standard chamber. Through a small observation port of pyrex glass, it was possible to secure excellent pictures of the flame at ignition, at full-flame and at cut-off.

Other applications in which the ultra high speed camera has furnished the industrial research engineer with important factual data include studies of high voltage discharges and of electric arcs in switchgear, etc.; of vibration and impact; of the action of metal during welding; of the behavior of materials during elongation; of the movement of flames in explosion of gases; of air and liquid flow — the list is endless. When this war is over and the larger story of high speed research can be told, a most important chapter in the annals of progress will find its way into our literature. Today, however, this new and remarkable tool is with us, ready and able to help in current problems of production as well as in the creative work on post-war products for tomorrow.

Janecek DISCUSSION

(*Continued from page 40*)

materials, you certainly are going to make the output of some of these furnaces tremendous. Secondly, there is going to be an improvement of some sort in putting these materials into the furnace. One of the things that has seemed to be wrong in the design of a large furnace today is the fact that we have been proceeding on the assumption that the ratio of the area of the stock line and of the big bell should be somewhat of a constant. That has led to the establishment of increased annular space between the bell and the stock line, which, according to some of the work we have been doing, is wrong; rather, the bell should be brought closer to the stock line.

In connection with that, I recently noted in a Russian article that the practice over there on the bigger furnaces with similar bells and stock line relations seemed to indicate that they were running with open walls, which is the way most of us are running today.

So I would like to inject a word of caution that perhaps we are nearing the point of diminishing returns to be attained from larger and larger units.

F. E. Kling: I agree with Mr. Martin on the maximum size of a furnace. A study made several years ago indicated that the economical advantages of large furnaces increase considerably from 600 tons to 1000 tons capacity. Shown on a chart in vertical position, the first part of the curve rises rapidly, but from 1000 tons to 1500 tons the curve flattens out gradually and is almost horizontal at 1500 tons. According to this study, it appears that, from the viewpoint of return on the investment, 1500 tons is the maximum desirable size furnace. Also, a very large furnace out of production has a severe effect on the total production.

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Power Circuit Breakers

. . . . new types of breakers operate on advanced principles of circuit interruption, giving industry safe equipment which eliminates some application and maintenance problems . . . .

by H. F. HENTSCHEL and E. W. BOEHNE

SWITCHGEAR DIVISION

GENERAL ELECTRIC COMPANY

PHILADELPHIA, PENNSYLVANIA

▲ DURING the past decade power air circuit breakers have graduated to the high voltage class. Not since the introduction of the station type low oil-content breaker have such thoroughly new interrupters, in improved equipments, met with such universal approval. There is a reason and a story behind this field-proven development which will interest all steel men. Retaining all advantages ever offered in oil circuit breakers, the metal-clad air circuit breaker offers many important additional performance features — features materially reducing cost of maintenance — features of special interest to the steel industry. It is the purpose of this paper to outline this transition from oil to air as the insulation medium in power circuit breakers, showing how the present air breaker developments offer the steel industries safe interrupters which function in such a manner as to overcome some of the present application and maintenance problems. The paper is illustrated with typical examples of industrial applications. It explains the underlying principles of the new breakers which reveal a new and interesting advancement in the art of circuit interruption.

THE ONE LINE DIAGRAM

In order to try to picture the significance of oilless circuit breakers in the steel industry, let us start with a typical electrical one-line diagram shown in Figure 1. This might represent a major mill power house with its station type generator breakers, its station type feeder breakers, and associated 2300-volt and 480-volt station auxiliary circuits — or the electrical one-line diagram might represent a typical plate mill substation with its main metal-clad mill operating breakers, step-down transformer to 480-volts a-c auxiliary circuit and control for mercury arc rectifiers or motor generator sets for producing the necessary 250-volt d-c general purpose power. Similar apparatus circuits will be found in most any other type of major mill substation, be it hot mill, cold mill, rod mill, or blooming mill. Or it might be the electric furnace room with its highly repetitive operating furnace breakers or the pumphouse or coke plant or any other substation in the mill, whether large or small. Every substation has electrical power circuits which can best be controlled by some form of an oilless circuit breaker.

STATION TYPE EQUIPMENTS

In the power house or generating station we find heavy duty station type air blast circuit breakers rated in interrupting capacity from 500,000 kva up through 2,500,000 kva and for service voltages 6900 up through 23,000 volts. These breakers, due to their physical size, are usually mounted in cubicle type structures similar to those used with the well-known low oil content breakers. Cubicles are complete with proper safety interlocked group operated disconnecting switches and associated current transformers, copper connections, and heavy duty bus assembled in a compact factory assembled steel housing. In Figure 2 is

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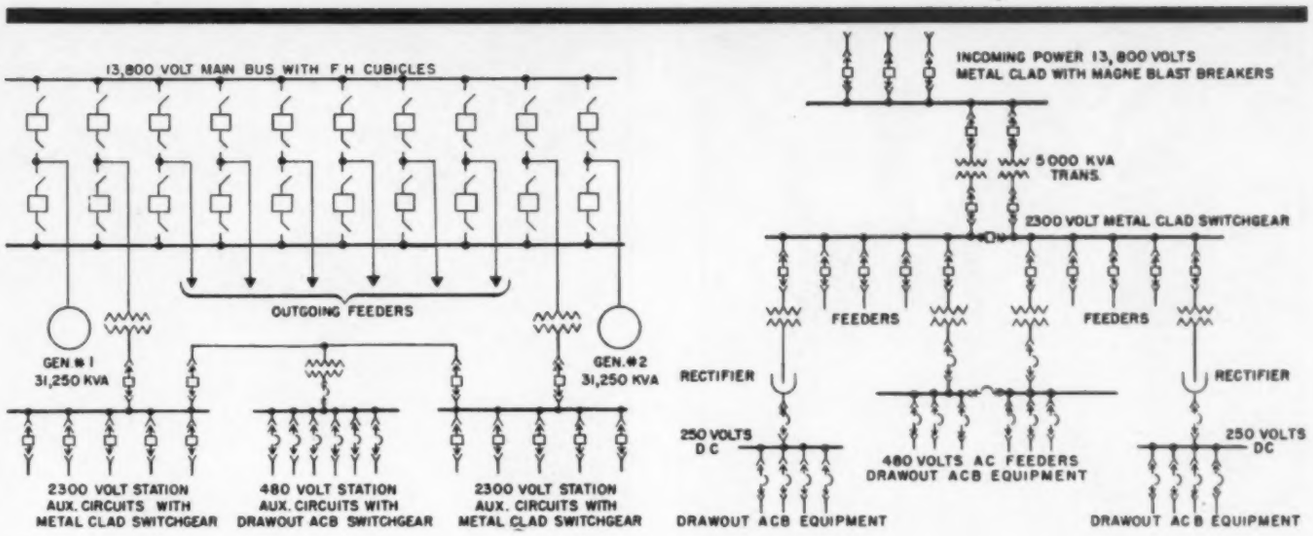


Figure 1 — Left, a representative one-line diagram of power house circuits. To the right is a representative one-line diagram of an industrial plant substation.

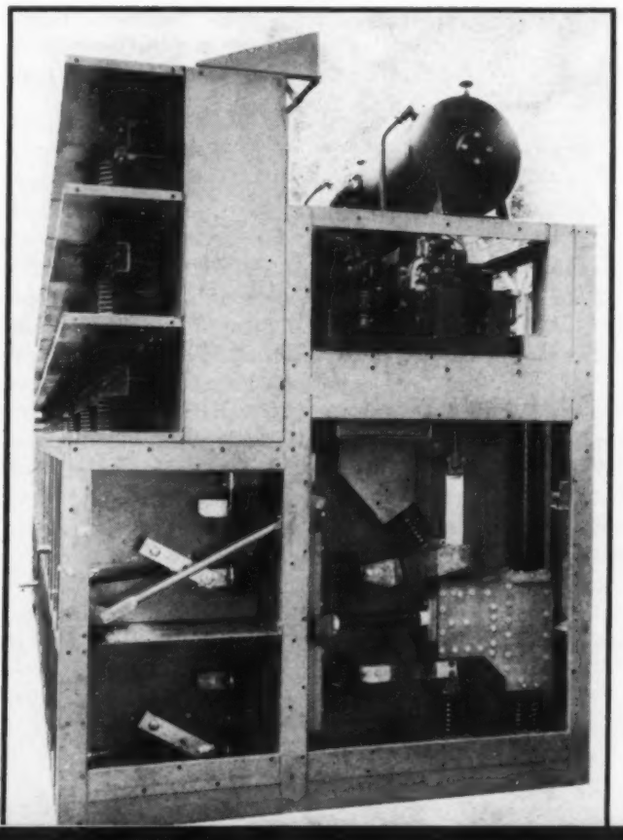
shown a cubicle structure with side plates removed showing arrangement of:

1. Modern station type compressed air blast circuit breaker, one million kva, 1200 amperes.
2. Air receiver and high speed trip-free pneumatic breaker operating mechanism.
3. Group operated isolating disconnecting switches.
4. Mechanical interlocks for breaker, switches, and doors, assuring safe sequence operation.
5. Heavy duty structural shape buses.
6. Heavy duty bus supports.
7. All copper interconnections have silver-to-silver current exchange surfaces.
8. Necessary current transformers.

All of this equipment is factory assembled in steel housing.

Being the backbone of the power system, these breaker structures are completely phase isolated, each phase of the breaker, its bus and associated disconnecting switches being mounted in a separate grounded steel compartment. This type of heavy duty breaker requires for its proper operation an external source of compressed air used for both breaker operation and circuit interruption. Figure 3 shows typical installed view of main power house cubicle structure of this type with twenty 1,000,000 kva, 13.8 kv air blast station type breakers.

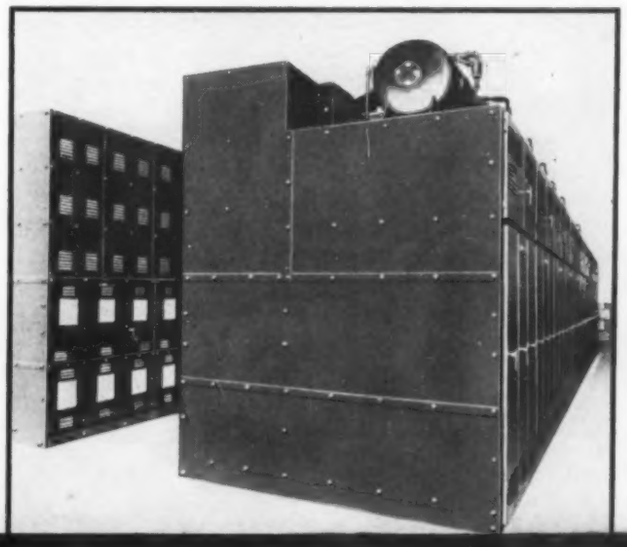
Figure 2 — Cubicle with station type compressed air-blast circuit breaker (side plates removed).

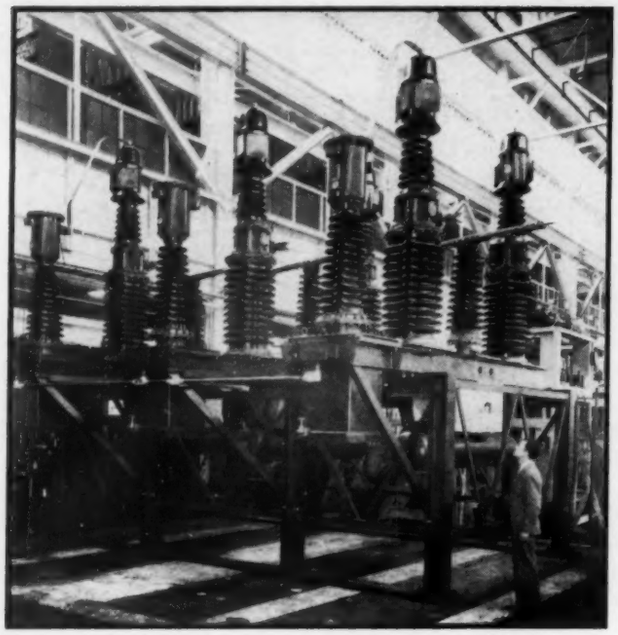


OUTDOOR HIGH TENSION BREAKERS

Where the power is being transmitted for long distances, outdoor step-up or step-down substations are

Figure 3 — Installation of 20 cubicles with station type air-blast circuit breakers.





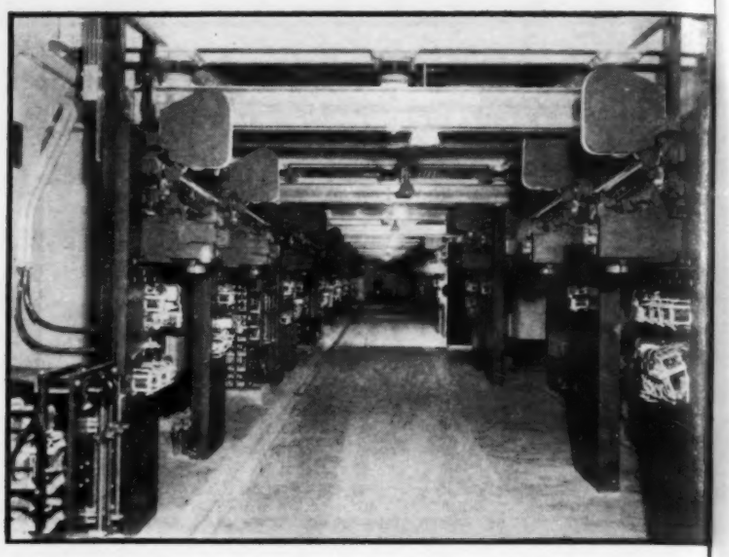
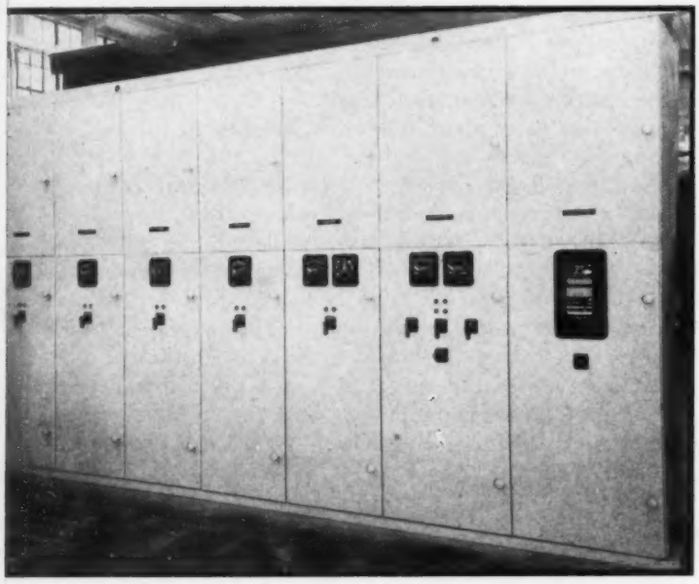


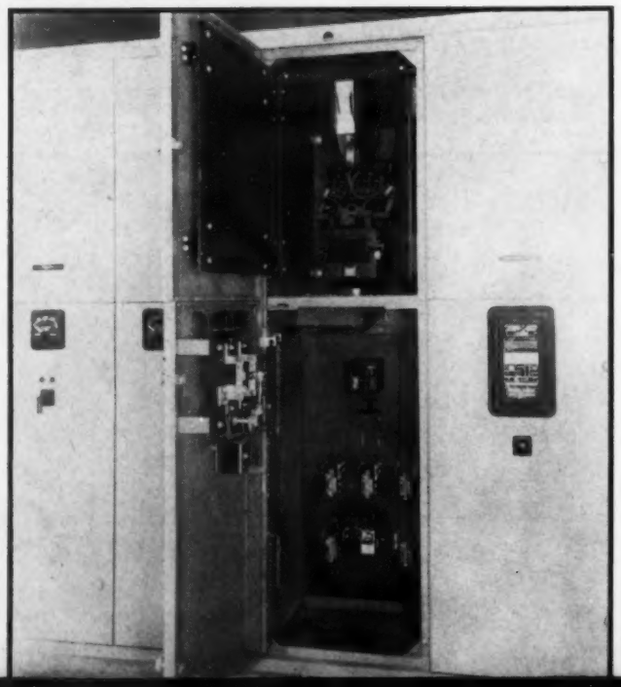
Figure 4 — Factory view of 138 kv outdoor air-blast circuit breaker. (above left)

Figure 5 — Hot mill basement showing mill type d-c air circuit breakers. (above right)

Figure 6 — D-c board for 250 volts with mill type air circuit breakers, doors closed. (center left)

Figure 7 — View of d-c board shown in Figure 6, but with doors open. (bottom left)





installed. Breakers in these outdoor substations, sometime in the future, will also be of the air blast type. High voltage outdoor type air circuit breakers are already in operation on systems rated 138 kv, 69 kv and 34.5 kv. These breakers are giving an excellent account of themselves and a wealth of operating experience has already been obtained for a guide in future designs. Figure 4 shows a 1,500,000 kva, 138 kv air blast circuit breaker. This breaker was installed in 1941. Like the heavy duty generating station type breakers, these outdoor high tension type air circuit breakers also require a reliable source of compressed air for their proper operation.

LOW VOLTAGE AIR CIRCUIT BREAKER EQUIPMENTS

In the low-voltage field, for service voltage of 600-volt a-c or d-c and below, self-contained magnetic type air circuit breakers have been the mill standard for a number of years. High interrupting capacity mill type d-c air circuit breakers — seasoned, time tested veterans of steel mill service — form the control centers of the country's major hot strip mills, such as the installation shown in the 600-volt hot mill basement aisle between the finishing mill motors and motor-generator set of one of the large continuous hot strip mills (Figure 5). Similar high capacity type d-c air circuit breakers provide a high degree of trouble-free protection for the 250 volt d-c mill shop source controlling generators, rectifiers, and d-c mill feeders (Figures 6 and 7).

The 480 or 240 volt a-c auxiliary circuits are controlled by drawout type air circuit breaker units. In

Figure 8 is shown a typical 480 volt low-voltage air circuit breaker structure being installed in a mill substation. Equipment is of the unit substation type with the roll-out air circuit breaker structure being throat connected to its step-down transformer bank. In these completely factory assembled low-voltage air circuit breaker structures each breaker is mounted on a draw-out carriage in a separate steel compartment. Breaker units of similar rating are interchangeable to prevent service outage or production delays during routine inspection. Mechanical interlocks of simple, sturdy design prevent removing or inserting the removable breaker element unless the breaker is in the open position, thus providing a safe guard for operating and inspecting personnel. Silver-to-silver contacts are provided for all primary and secondary current exchange surfaces thus minimizing heating and reducing maintenance.

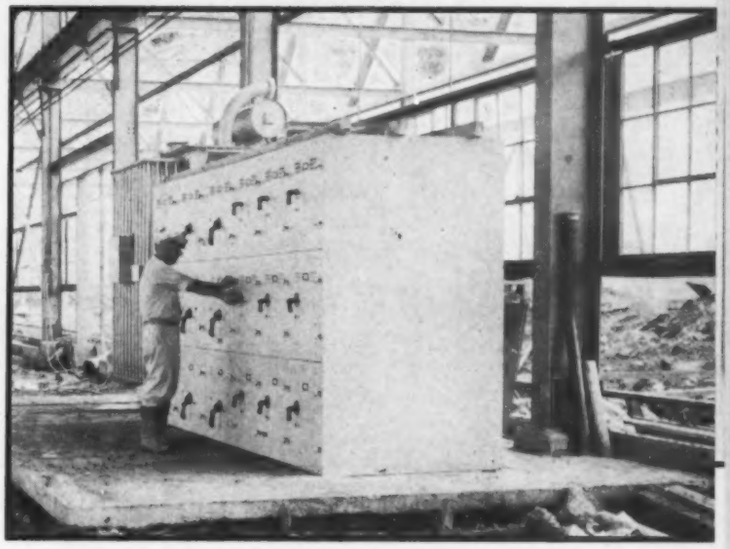


Figure 8 — Unit substation with 480 volt roll-out air circuit breakers.

MILL SUBSTATION TYPE BREAKERS

Although each of these different types of breakers play its part in the operation of the mill, the real burden of production falls on the mill substation or mill operating breakers. For the past decade, vertical lift metal-clad with oil circuit breakers of the self-contained type, having all three phases in one tank, and with published interrupting capacity up through 500,000 kva, have been the recognized mill standard for this class of service.

Earlier installations were of the truck type, wherein the oil circuit breaker, its current transformers, and associated protective relays and metering equipment were mounted on a removable truck (Figure 10). This type of equipment, although comparatively safe in operation, had much to be desired in the way of interchangeability of breakers and ease of breaker maintenance. Also, some of the old installations were of the cubicle type or open framework type with non-removable breakers, with bare bus and connections and bare isolating disconnecting switches. (Figure 11.) Here also exposed bus and connections and open disconnecting switches were a continual hazard and breaker units were not readily accessible for maintenance. These old installations included the then standard utility type oil circuit breakers. It was soon found that better and more scientific interrupters, mechanically stronger, had to be manufactured to stand up under the repetitive operation requirements as would be found in a-c reversing duty or furnace application.

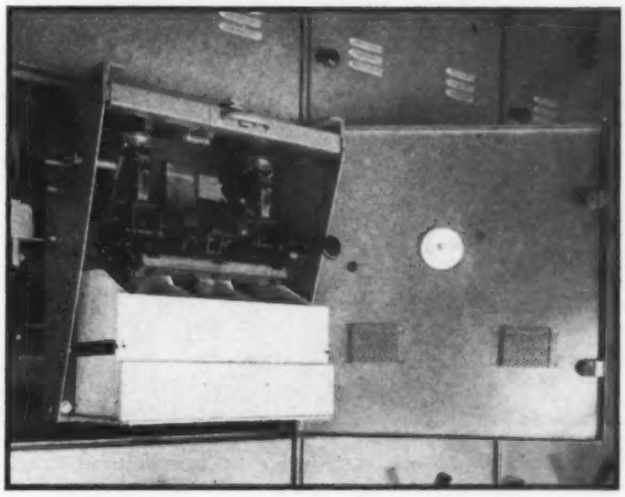
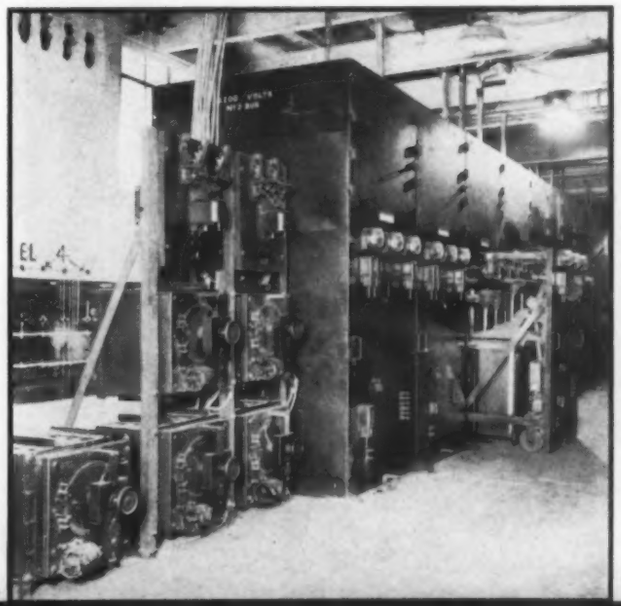


Figure 9 — Low voltage air circuit breaker equipment showing breaker compartment, door open.

▲

Figure 10 — Early truck type switchgear.



Improvements in the mechanical parts of the breaker and its operating mechanism were the answer to minimizing mechanical maintenance. Vertical lift metal-clad equipment was the answer to safe and easy accessibility of the breaker for maintenance. To the engineers of the steel industry belongs a great deal of credit for their share in the development and improvement of modern vertical lift type metal-clad equipment. They were among the first to see the need for, and readily accept, metal-clad gear and there can be no doubt that the present high standard of this type of equipment was very much influenced by mill requirements.

Mechanically, and from a safety standpoint, the modern metal-clad type oil circuit breaker is doing an excellent job; however, there is always that somewhat

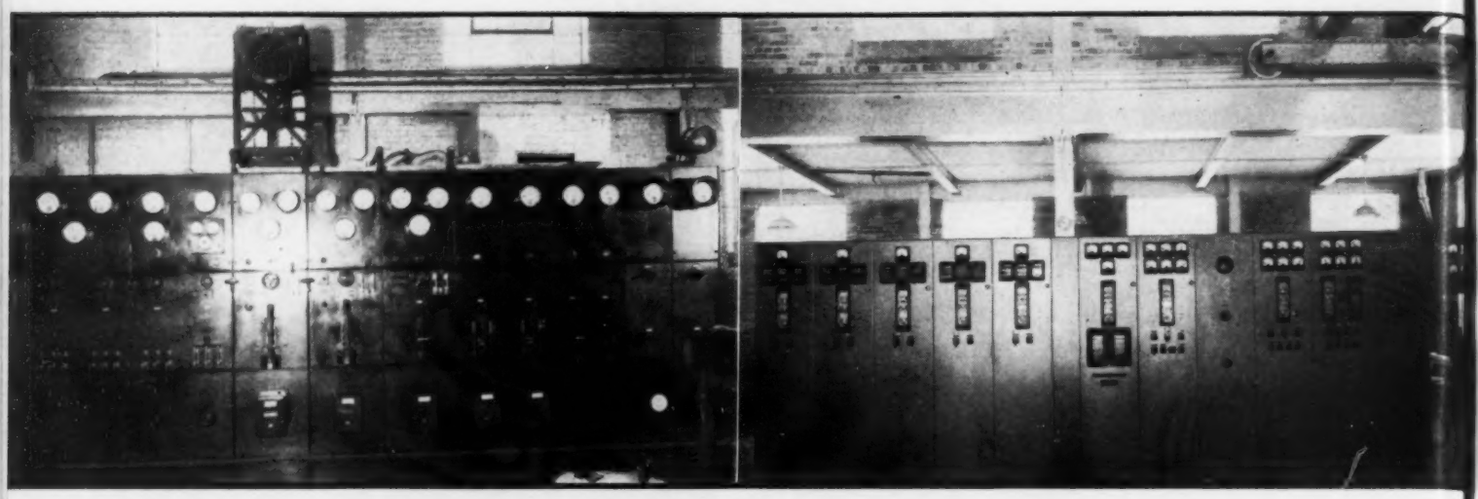


Figure 11 — Old installation of open type switchgear, as compared with typical metal clad switchgear with magnetic blowout air breakers.

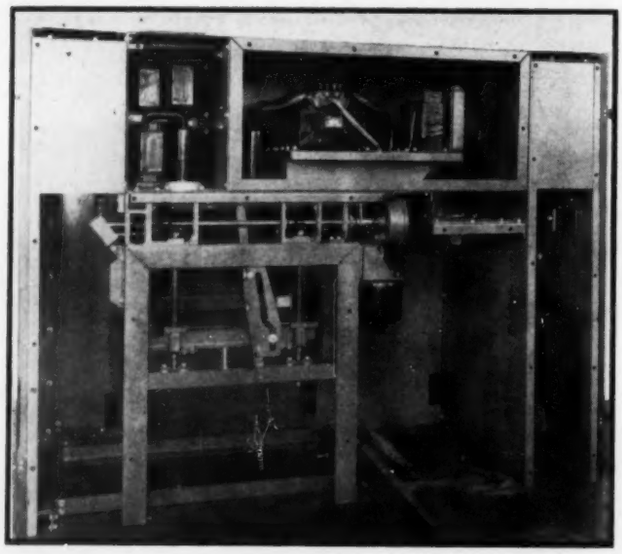


Figure 12 — Metal clad unit with side removed.

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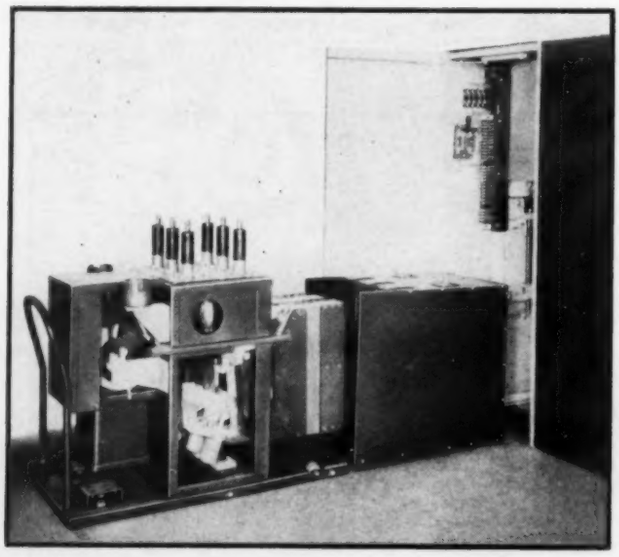
Figure 13 — Magnetic blowout air circuit breaker removed from metal clad structure with box barrier removed from the breaker.



remote oil fire hazard and the continuous maintenance required due to oil deterioration under arc. Oil changing, oil filtering, oil testing, oil storage all add their problems and menace factor.

By uniting the fundamental principles of magnetic action and thermal reaction, engineers have created a new type of self-contained air interrupter — the magnetic blowout air circuit breaker. Already thousands of these breakers are in operation in spite of the fact that they have been available for only approximately three years.

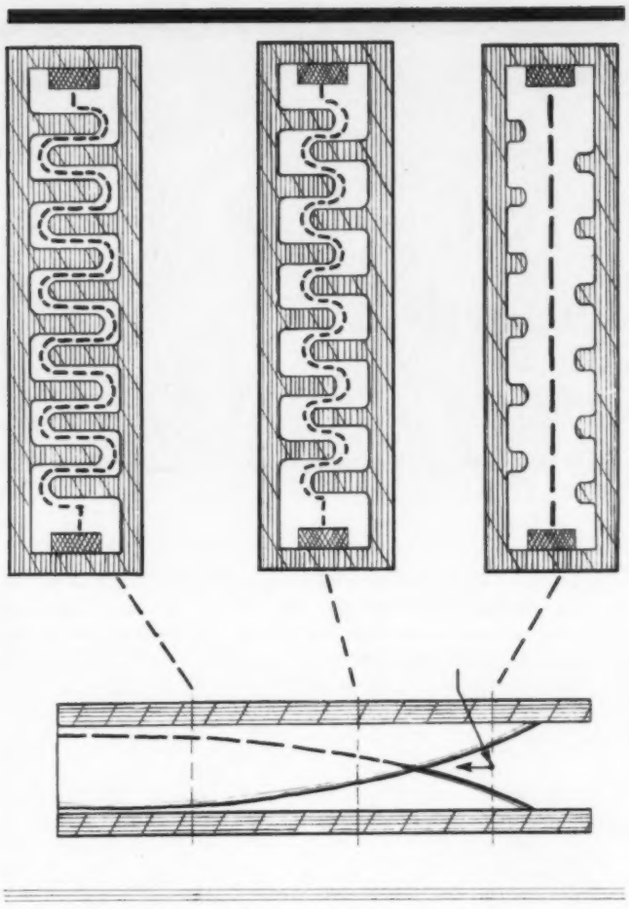
These magnetic blowout breakers are operating in the mills around Chicago, Pittsburgh, Cleveland, Buffalo, Birmingham, Detroit, and practically every other small or large steel mill center. Breakers have been installed in the mines and mills from the hot humid climate of the Canal Zone to the frozen parts of Alaska, performing equally well under all conditions. These breakers are available for service voltages in 25, 50 or 60 cycles with interrupting ratings as follows:

For service voltage up through 5 kv, such as 2300 or 4160 volts, in interrupting ratings of 50,000, 100,000 and 150,000 kva.

For service voltage up to 7500 volts, such as standard mill operating voltage of 6600 or 6900 volts, in interrupting ratings of 250,000 and 500,000 kva.

For service voltage up through 15 kv, such as 11 or 13.8 kv, in interrupting ratings of 250,000 and 500,000 kva.

By applying sound, sensible system application principles, the interrupting requirements for practically all modern mill substations have been held within the ratings covered by these self-contained vertical lift metal-clad type magneblast air circuit breakers. These breakers, as will be noted, are manufactured with the same configuration as the metal-clad oil circuit breakers and are supplied in standard vertical lift metal-clad structures retaining all of the features of safety, ease of maintenance, ease of installation and operating advantages now incorporated in standard mill type gear. The structures (Figure 12) are identical with those used with the oil circuit breaker and consist of a separate compartment with its sturdy screw jack type lifting mechanism for housing the air circuit breaker, separate



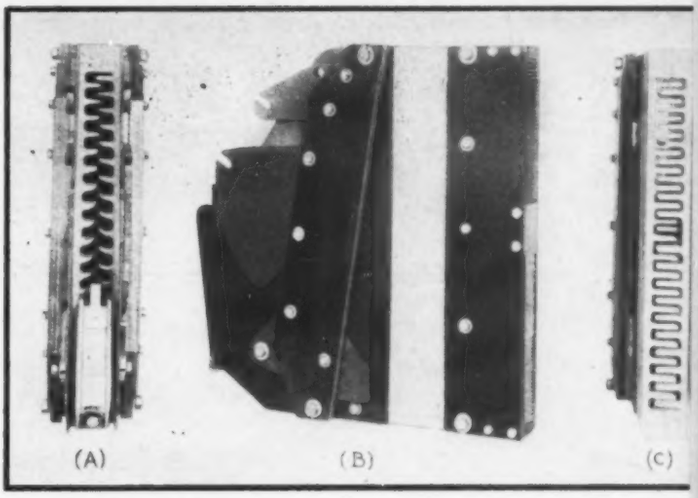
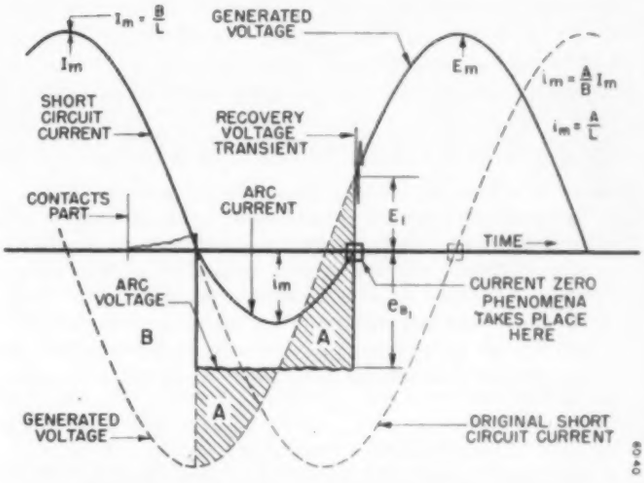
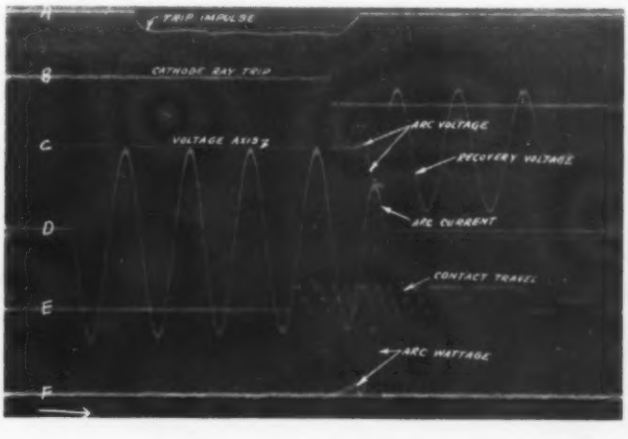


Figure 14 — Diagramatic view of the interleaving arc chute of the magnetic blowout air circuit breaker showing the everlengthening path as the arc is driven magnetically into the chute. (left)

Figure 15 — Three views of an arc chute embodying the interleaving principle shown in Figure 14. (A) throat view, (B) side view, (C) exhaust end (without muffler). (above)

Figure 16 — Diagram and oscillogram showing the action of the high arc voltage produced by the interleaving arc chute in lowering the arc current and permitting the current zero to take place at a low value of generated voltage. (below)



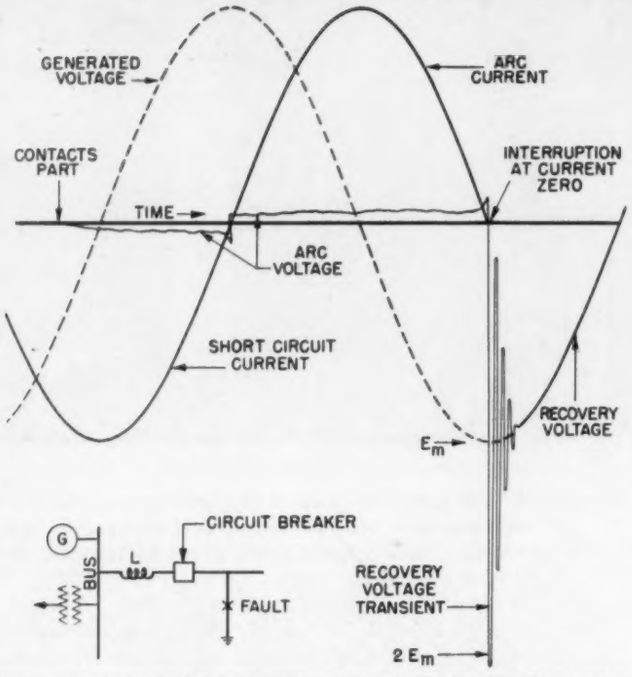


compartment for the completely insulated triangular shaped bus construction designed to withstand heavy short circuits, separate compartment for the current transformers selected or coordinated to withstand maximum short circuit currents equivalent to that of the breaker with which they are to be used and separate compartment for the secondary control consisting of instruments, meters, control switches, and completely coordinated overlapping relay protection.

Magnetic blowout a-c breakers are easily removed from the metal clad structure, and main current carrying and arc contacts are exposed and visible for inspection by merely unbolting a few wing nuts and sliding off the box barrier. In Figure 13 are shown breakers removed for inspection with box barrier removed to show the visibility and easy accessibility of the contacts. So easily and quickly can the breaker be removed and inspected that it is not uncommon for furnace breakers to be inspected between heats without delaying the furnace operation.

DESCRIPTION OF THE MAGNETIC BLOWOUT PRINCIPLE

The magnetic blowout circuit breaker is a power circuit breaker which opens its contacts in air and permits the resulting arc to be blasted magnetically into a non-metallic labyrinth chamber which acts upon the arc in three specific ways to effect a quick and efficient interruption. The three actions of the arc chute are: (1) To lengthen the arc by forcing it into the interleaving arc chute shown in Figure 14; (2) to squeeze



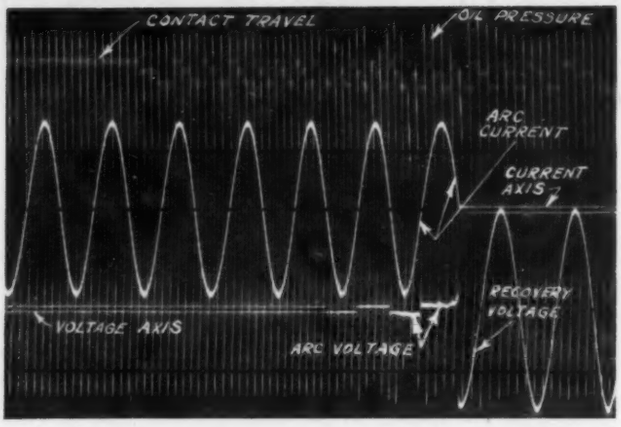


Figure 17 — Diagram and oscillogram revealing the corresponding action of the oil circuit breaker showing the current zero taking place in the presence of maximum generated voltage.

the arc to a small cross section; and (3) to provide for efficient and rapid cooling of the arc in a non-gas producing chamber. These three functions of the arc chute all act to rapidly increase the arc resistance. This increasing arc resistance functions like a rheostat which is suddenly "dialed" into the circuit with the result that the current is reduced to a fraction of its former value in less than one cycle of arc. The resulting arc energy is small and is so uniformily distributed over the entire arc chute surface that the ultimate temperature rise of the arc chute, following the interruption of the heaviest short circuit, is only a few degrees and is of no consequence.

The fault current, prior to contact parting, is practically a 100 per cent lagging current in which the interrupting current zeros occur in the neighborhood of maximum generated voltage. In the brief arcing period following contact parting (one-one hundredth of a second), the arc resistance has not only reduced the current but has converted the circuit close to unity power factor in which the interrupting current zeros now occur in the neighborhood of a voltage zero. This action simplifies the mechanism of current extinction.

Figure 16 exhibits such a performance. This is shown in comparison with the interruption of the same circuit by a conventional oil circuit breaker Figure 17. The oil breaker gives rise to a small arc voltage and the final current zero occurs at a time when the recovery voltage is at its maximum. Hence, a recovery voltage transient (Er) occurs which may rise to twice this crest value. This voltage, the oil breaker is equipped to withstand by reason of the dielectric strength of the oil. The corresponding performance of the magnetic blowout breaker, however, introduces the high arc voltage (e_a), reduces the arc current (i_a), and at the current zero the recovery voltage (E_l) is so low that interruption is more than assured. This shifting of the current zero, together with the reduction in arc energy, by

Figure 18 — Comparative actions of the magnetic blowout and oil circuit breaker in the region of current zero, revealing the nature of the current zero phenomena which favors the air circuit breaker. (a) The magnetic blowout breaker's action is mild — no high surge of recovery voltage after current interruption. (b) An oil breaker's action on interruption of small currents is followed by high surge of recovery voltage.

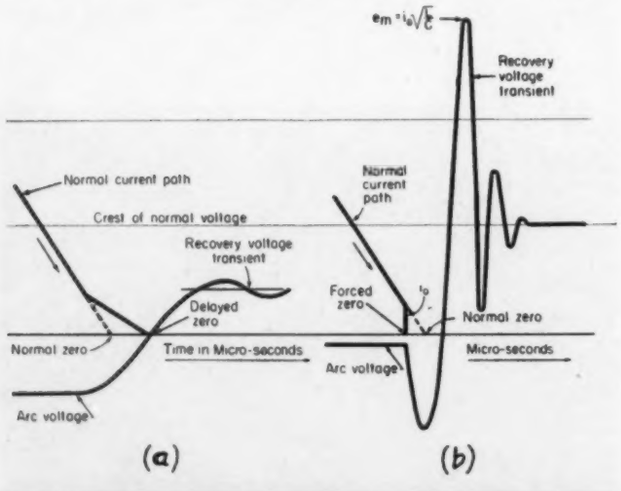
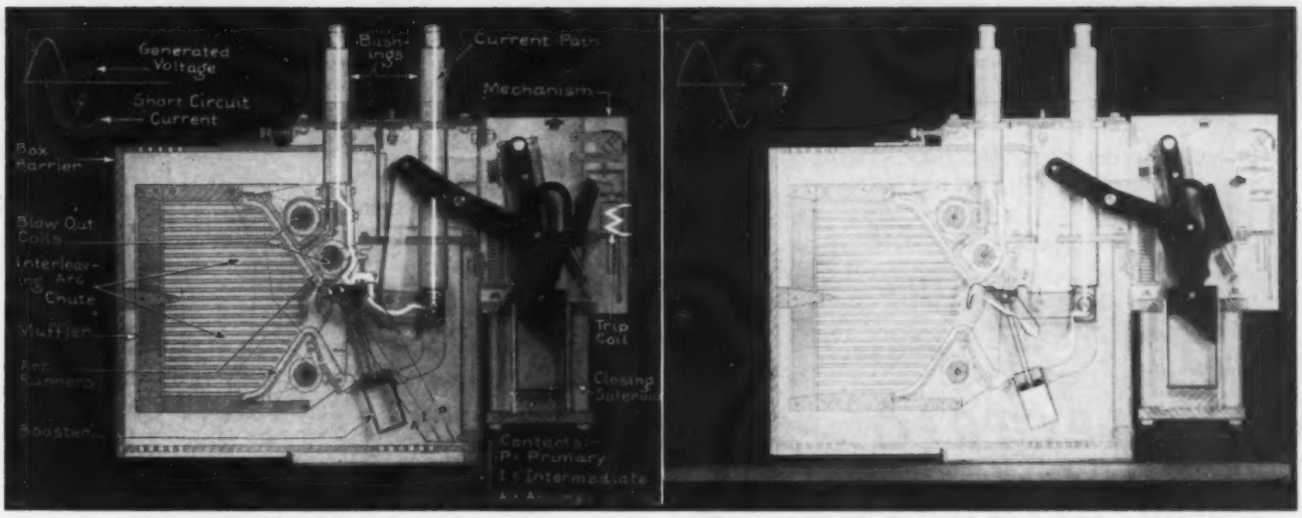
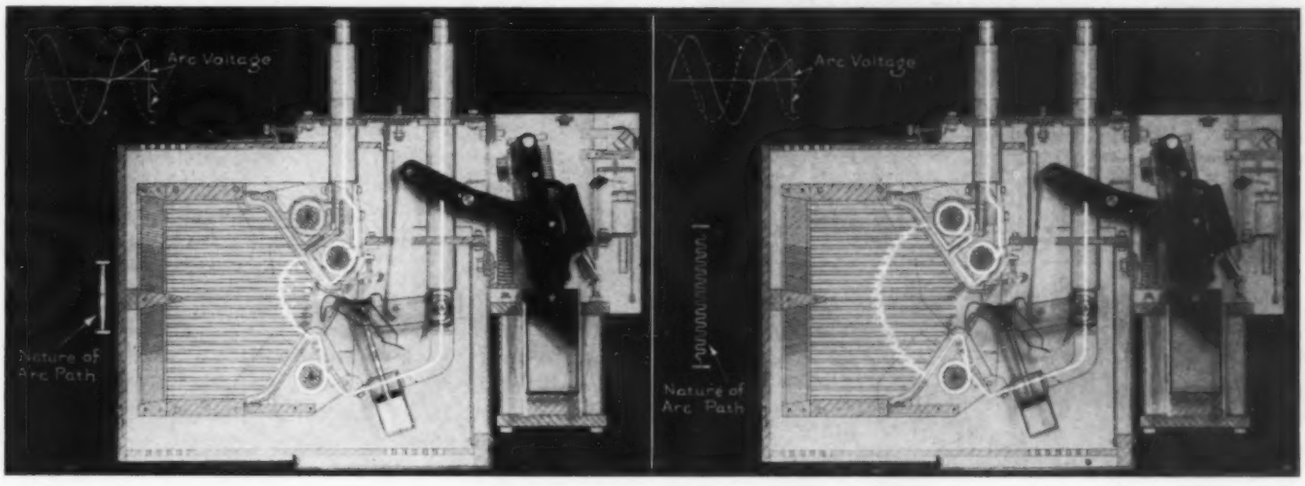


Figure 19 — The action of the magnetic blowout air circuit breaker as depicted by the portable demonstrator. In these cross section views, half of the interleaving arc chute is removed to visualize the nature of the arc path. In the upper left corner of each view a typical oscillogram record is shown synchronously with the breaker operation. The current path thru the breaker is revealed by the white line. (opposite page)



(a) The closed breaker, trip coil energized. The blow-out coils carry no current while the breaker is in the normally closed position.

(b) As the intermediate contacts part, the current is shunted into the first blowout coil before the arcing contacts part.

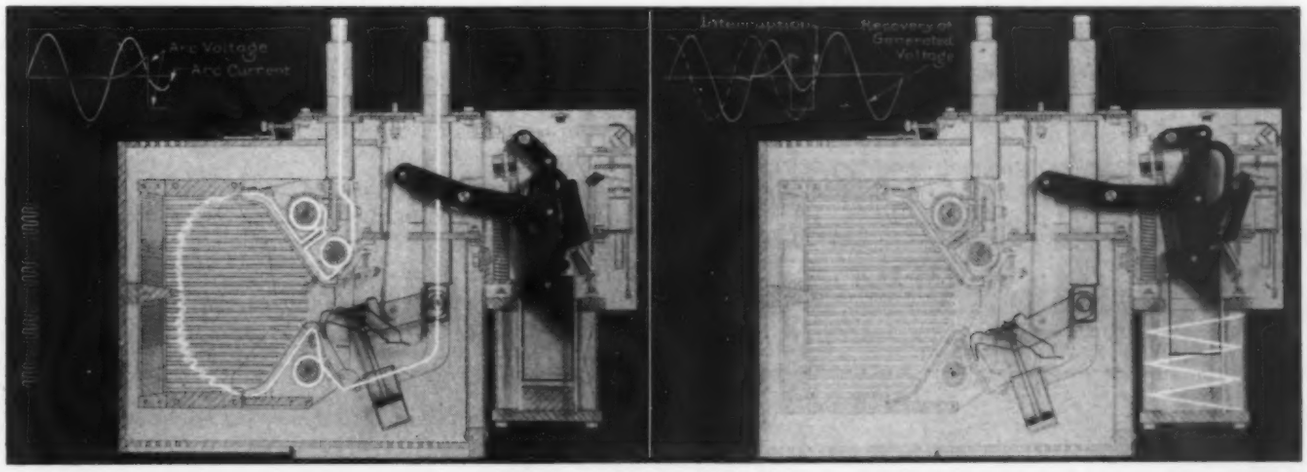


(c) As the arcing contacts part, the arc is magnetically blasted into the arc chute, the arc roots running along the runners at sufficient speed to leave only the slightest surface scars. Small magnetizing currents are transferred more rapidly to the runners by aid of the air jet provided by the booster.

(d) As the arc proceeds, more coils enter the circuit. The arc is driven into the interleaving structure (see Figure 14) where a high arc voltage is produced, which acts to decrease the circuit current and permit the interrupting current zero to occur at low values of generated voltage.

(e) The oscillogram in the upper left corner exhibits how the arc voltage acts to reduce the current and effect these mild interrupting characteristics (see Figure 16). No visible fire or flame is emmitted from the breaker even when interrupting its full capacity.

(f) At the first current zero within the outer half of the arc chute interruption occurs. The recovery characteristics are further benefited by the desirable current zero phenomena shown in Figure 18a). Total arcing time under fault conditions is less than one cycle.



developing the high arc voltages, is the contribution of the magnetic blowout principle to the art of circuit interruption.

SOLUTION OF SOME INDUSTRIAL APPLICATION PROBLEMS

The circuit breaker in the industrial application is required to perform many operations under varied circuit conditions and still at all times stands ready for immediate action in the event of a short circuit. The oil circuit breaker, under favorable conditions and when properly maintained, does an admirable job. The insulation, however, is expendable, oil carbonization being a function of the total kva interrupted. Moreover, when required to interrupt the small magnetizing current of the power transformer, the oil breaker is "too efficient" and gives rise to current gradients which cause overvoltage under certain circuital conditions. These conditions all accumulate in the application of oil breakers to the arc furnace circuit. Here four separate currents require interruption: (1) the load current, (2) heavy overload currents, (3) magnetizing current of arc furnace transformer, and (4) primary short circuit currents between the breaker and the transformer of which only few occur; 50 to 100 breaker operations a day is not uncommon. All produce oil carbonization which reduces the effectiveness of the insulation. Surges produced by the small magnetizing current interruption are not compatible with such reduced insulation. These conditions have necessitated the highest brand of maintenance to insure adequate service on this type of load to maintain the maximum steel output.

The magnetic blowout breaker embodies features which eliminate both of these undesirable characteristics. Having no oil, the carbonization problem vanishes. The arc chute, instead of deteriorating with use, is actually known to improve with use. On light current duty, interruptions occur without producing surges even under the most pessimistic circuital environment. Small currents, including magnetizing currents, are assisted into the arc chute by means of the small air booster shown in Figure 13. This small amount of free air directed at the arc permits efficient transfer of the small currents to the arc runners and into the arc chute where interruption is prompt and without the hazard of surges. Breakers of this type have been oscillographically tested on 15 kv arc furnace circuits to confirm the results of laboratory tests. Numerous installations of these breakers to 15 kv arc furnace duty have been made with notable success. This type of application has been cited in detail to demonstrate the successful solution of one of the most difficult circuit breaker application problems in the steel industry.

Other inherent features contribute to low maintenance requirements. The arc in the magnetic blowout breaker is in continuous motion, the arc roots moving out on the metallic runners at express train speed. The arc roots are never in any one place long enough to leave more than the slightest surface scar. This contributes to a minimum of arc contact burning. The arc chute is provided with a muffler which confines the arc to the chute and also prevents arc flame from appearing on the outside of the breaker during the heaviest interrupting duty. This makes it quite adaptable to the metal-clad enclosures, in which it has been tested, and which in turn protects the breaker from direct dirt precipitations sometimes associated with some industrial applications.

In executing these designs consideration has been given to the coordination, both electrically and functionally, with the complete metal enclosed assembly. This packaged, easily installed equipment has contributed to the safe, trouble-free service which has enabled the steel industry to achieve the recent outstanding industrial record of all time.

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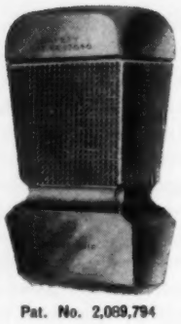

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WATER AND COMPOSITION

Roll Neck Bearings

. . . . reviewing some factors influencing the performance of composition bearings on roll necks . . . . water temperatures should not exceed 113 F . . . .

by J. P. QUEENEY

ENGINEER, PLASTICS DIVISION

GENERAL ELECTRIC COMPANY

PITTSFIELD, MASSACHUSETTS

▲ MANY articles and papers have been written on the design and use of phenolic laminated bearings for steel mill applications. They have proved their worth under many conditions. Plastic bearings are now being used on blooming mills, plate mills, bar and billet mills, rod mills, strip mills, skelp mills, tube mills, three-high sheet mills, structural mills and practically any place where water lubrication may be used.

Information about the savings effected by using composition bearings (such as power, grease, roll life, increased tonnage, lower scrap loss, long bearing life and more accurate gage) has been widely published and this subject will not be further discussed here. Rather, this article attempts to examine the effect that the temperature, purity, and amount of lubricating water has upon the successful operation of phenolic laminated bearings.

To begin with, it is fortunate that composition bearings operate successfully with only water as a lubricant, because one of the main factors in any friction calculation is the viscosity of the lubricant. Water, having a viscosity of only 1, therefore has a tendency to greatly lower the coefficient of friction of any bearing where it is used as the only lubricant.

It is well known that in some mills where water temperature is much lower in the winter than in the summer, the life of the bearing is shorter in hot weather. Tests were run to find the friction characteristics of plastic bearings at various loads and speeds in relation to the temperature of cooling water.

To begin with, observe the coefficient of friction of composition bearings under ideal conditions.

Figure 1 shows the friction characteristics of a composition bearing at pressures from 3000 to 4000 psi and speeds from 125 to 2100 fpm. Note that the curves flatten out at about 400 fpm and remain that way for the higher speeds, with a coefficient of friction of .003 to .005.

This test was run using clean, fresh water at about 25 to 30 C (77 to 86 F). This low coefficient of friction indicates that the journal was riding on an actual water film. If this is true, and if a water film can be maintained, then a lower coefficient of friction should be found at the higher water temperatures due to the decrease in viscosity of the water at these higher temperatures.

Figure 2 shows the viscosity of water as a function of temperature, and indicates that the viscosity is cut in two by raising the temperature from 20 to 50 C (68 to 122 F). Therefore, if in practice we actually get higher friction at these elevated water temperatures, there must be some breakdown of the water film. This causes hot spots to develop in the bearing which increase the rate of wear. Obviously, a large flow of water, even at these higher temperatures, will help eliminate hot spots, so for test purposes we used a large flow of water — about .6 gal per min per sq in. of bearing area — and applied it by means of slotted spray pipes similar to Figure 3. This allowed the water to cover all exposed parts of the journal surface. Since the tests were run to find the effect of temperature of the water rather than that of the amount, this was a sufficient flow of water. The journal was driven by a cradle type dynamometer operating as a separately excited d-c motor with speed control. The torque reaction was measured by the dynamometer beam scale, and a recording ammeter was placed in the armature circuit to record the fluctuation of current, which is proportional to torque and can be calibrated in ft-lb by referring to the corresponding beam scale readings.

The tests were started with water at about 25 C (77 F). Water temperature was increased in steps of 5 C at 10 min intervals. The results will be seen in Figures 4 to 7. Figure 4 shows performance at 2000 psi and a rubbing speed of 1000 fpm. Here, note that the operation was quite stable up to 66 C (151 F). At this point, the water film broke down and a hot spot developed which caused the bearing to seize and stop the test. At the beginning of this test, the surface of the journal was of a dark color with a high polish. The finish

remained on the shaft until the water film broke down. Then the finish was rubbed off and the shaft became bright.

Figure 5 shows the same conditions of load and speed, but in this case different bearings were used which had harder and more stable structure due to a recent annealing process developed together with new alloyed resins. Notice this operation was stable up to a temperature of 86 C (187 F). In trying to raise the water temperature to 91 C it was found that the water film broke down and the bearing surface was burned.

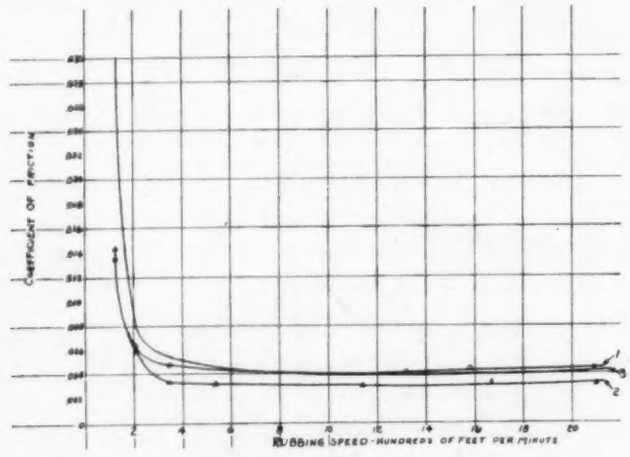


Figure 1 — Curves showing variation of friction with rubbing speed.

Figure 2 — Curve showing the variation of viscosity of water with temperature.

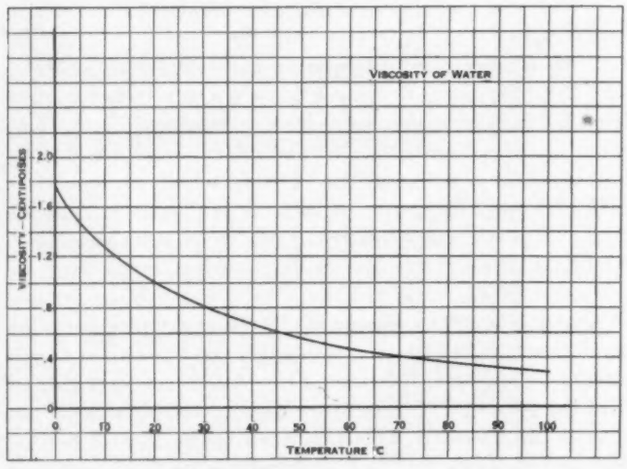


Figure 3 — Suggested spray pipe to replace pipes with drilled holes on composition roll neck bearings.

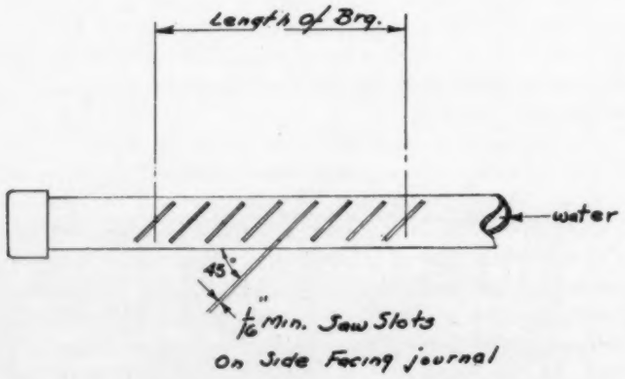


Figure 6 shows bearings identical with those in Figure 5 but operating at 2000 psi and 600 fpm. In this case there was fairly stable operation up to 84 C (183 F).

Figure 7 shows the same bearing operating at 3000 psi and 600 fpm. The temperature was run up to 74 C (165 F) and then lowered to see if the bearing would recover its low friction. When the test started, the friction coefficient was about .003, which then rose to a maximum of about .012 and then decreased to about .005. After completing this test, these bearings were run for an hour at 2000 psi and reached a coefficient of .002.

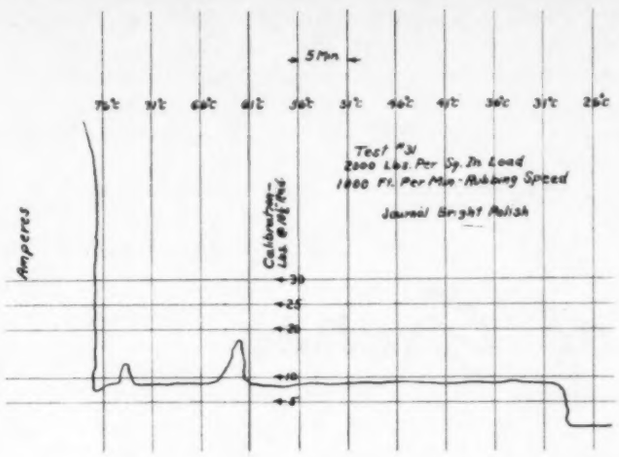
From these tests it is evident that by supplying plenty of water to composition bearings, it should be possible to operate them successfully where water temperatures do not exceed about 45 C (113 F). This water temperature is as high as any likely to be used in a mill. Of course, phenolic bearings must be made with a binder which is very hard and thoroughly cured in order to avoid unstable operation and hot spots.

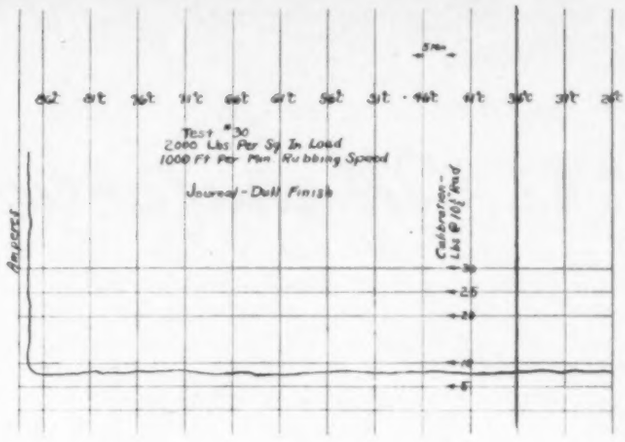
Smoothness of neck surface becomes more important as the temperature of the cooling water rises. Journals operating for a period of several hours under heavy loads but low friction often develop a very dark colored surface with a high polish. A high coefficient of friction will rub off this color and leave a bright surface. At this time, it might be mentioned that the fillet on the roll necks should be accurately ground to a smooth finish at the time the necks themselves are ground. Failure to do this results in poor lubrication of the thrust collars and causes excessive and rapid wear.

Tests have indicated that a small amount of grease injected into the bearing at infrequent intervals tends to stabilize the friction coefficient. This grease seems to imbed itself into the surface pores of the bearing and acts as a secondary defense against hot spots when the water film fails momentarily. This has been verified by reports of operating men. The practice of swabbing roll necks with grease when the mill is shut down is also beneficial in this same way.

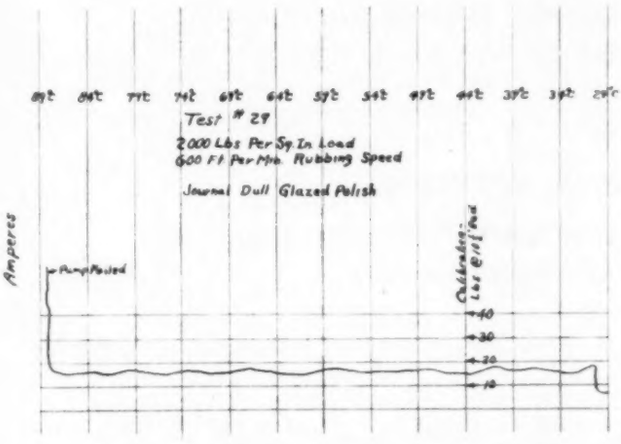
The purity of cooling water is important in many ways. Acids or salts in the water, while having no effect on the phenolic bearing, often corrode the surface of the roll neck due to electrolytic action and prevent the maintenance of a smooth journal surface. This results in shorter bearing life. This effect is much more pronounced when the temperature of the cooling water rises above 90 F. This corrosive action is also found in cases where salt water has been used for cooling. The use of lime or similar material reduces this action and helps purify the water. Water should also be free from suspended sand or dirt, which blocks spray pipe openings and scores the roll neck if allowed to enter film area. For this reason many mills have found it economical to condition their water with a filter system. In order to get the best efficiency out of the cooling water, the spray pipes should be designed to bring as much of the cooling water as possible into intimate contact with the neck surface. As many jets of water as practical should be employed and they must impinge on all of the available open neck surface.

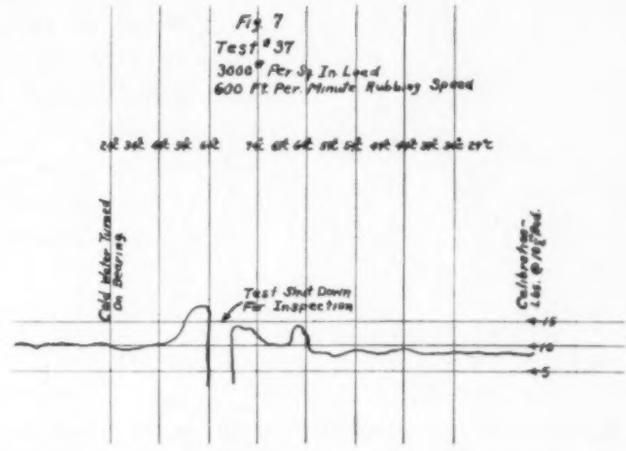
It is evident from the foregoing tests that composition bearings in order to operate at their highest efficiency must be supplied with clean, cool water for lubrication and cooling. This water must be applied correctly and





Figures 4, 5, 6 and 7 — Curves giving results of tests to determine the effect of water temperature upon the performance of composition bearings.





in enough quantity, the amount being much more important than pressure.

It is interesting to see the very low friction coefficient of phenolic laminated bearings when under heavy bearing pressures, as indicated by Figure 1. This coefficient of friction is so low that it indicates that there must be film lubrication existing. When we examine the characteristics of phenolic laminated materials for an explanation of the stability of this low friction, one characteristic immediately stands out. This is the material's very low modulus of elasticity (approximately 500,000 psi per inch deflection).

According to the usual theory of oil film lubrication, where rigid bodies are assumed the pressure within the oil film is dependent upon the viscosity of the fluid, the thickness of the film, the relative velocity of the bearing and journal surfaces, and the angle between the two surfaces. With rigid bodies, there is a considerable concentration of the bearing pressure at the point where the lubricating film is thinnest.

Consider, however, the altered conditions of this theory when the bearing is made of material which is many times more elastic than the commonly used metal bearing. As the pressure within the lubricating film increases, or tends to concentrate at the point of minimum thickness, such pressure is sufficiently high to cause considerable deflection or compression of the bearing lining. This distorts the lining so that the lubricating film does not decrease in thickness as much as it did with a rigid bearing under the same total loading. The net result is a more even distribution of pressure throughout the lubricating film, less concentration of pressure, and a tendency toward stability.

The non-metallic structure of composition bearings is of such a nature that, when brought into close contact with the metal roll neck, they have no tendency to adhere, contrary to the tendency of metallic bearings. This fact results in less galling and scoring of the necks.

Summing up, we have the following conclusions:

1. Lubricating and cooling water should be clean, cool and free from corrosive forming salts and acids.
2. Sufficient flow of water must be maintained. (Tests indicate a minimum of .6 gal per min per sq in. of projected bearing area).
3. Water must be applied correctly to insure maximum contact with necks.
4. Water temperature should not be above 45 C (113 F).
5. Roll necks should be ground smooth, including fillets.
6. Water at high temperature results in lower coefficient of friction up to a certain limit because of its lowered viscosity. Beyond this limit, the water film breaks down and hot spots develop.
7. Swabbing heavy oil or grease to necks at shutdown helps to prevent hot spots as well as rust.

THE *Manufacture of Grease*

. . . . grease making has been lifted from a secret "mystic art" to a scientific procedure . . . . although accurate testing procedure is used to control grease manufacture, actual service tests must be the final criterion of application . . . .

by L. P. LOCHRIDGE
SINCLAIR REFINING COMPANY
NEW YORK, NEW YORK

▲ GREASE manufacturing, until recent times, has been regarded as a personal art. Grease makers considered themselves to be a group apart, gifted with an uncanny ability to combine oils and soaps in mysterious ways to make still more mysterious greases. The accumulation of modern scientific knowledge together with accurate test instruments and controls have established grease making today as a definite science. This has been of great assistance in the field of lubrication. It is now readily possible, where formerly it was very difficult, to produce batch after batch of grease with standard characteristics. This is a far cry from the day when the old time small town grease maker pulled down the window shades and closed the shutters, lest some inquisitive neighbor should spy out his devious methods and formulae.

MANUFACTURING INGREDIENTS

The basic materials used in the making of grease can be summarized briefly:

1. Mineral oil.
2. Saponifiable fat.
3. Metallic base or saponifying agent.

The saponifiable fat, which consists of tallow or animal fatty acids or hydrogenated fish oils is heated in contact with a saponifying agent or agents, such as calcium hydroxide or sodium hydroxide to make the grease soap. The mineral oil and the hot soap solution are then combined in the proper quantities to give the desired consistency. Each ingredient is tested prior to use and all manufacturing details such as temperatures and stirring speeds are strictly controlled.

For convenience, greases are classified into three groups depending on how they are manufactured. These are as follows:

1. Sett greases.
2. Cold made greases.
3. Cooked greases.

SETT GREASES

Sett greases are made by mixing mineral oils, rosin oil and sett at temperatures less than 150 F. Sett is an emulsion containing hydrated lime, mineral oil and a small amount of rosin oil. For special lubricating needs various fillers may be used. In general, these greases are of the cheaper grades used for rough service such as skids, track curves, wagon axles and centre plates of cars.

COLD MADE GREASES

The procedure for making cold made greases is first to dissolve the saponifiable fat in the mineral oil. The mixture is then held at a temperature between 100 and 110 F. The caustic soda metallic base, which has been dissolved previously in the proper amount of water, is then added. The entire mixture is then stirred thor-

oughly to insure the proper reaction of all the ingredients. This stirring is continued until a slight rise in temperature indicates that the formation of the grease is beginning. The grease is then placed immediately in containers where the reaction continues and in a short time, reaches a conclusion. This reaction causes the grease to solidify and to assume its final consistency and appearance. Greases of the cold made type are:

1. Rod cup grease.
2. Rod cup grease green.

COOKED GREASES

The majority of greases fall in this classification. The lime, soda, aluminum, lead base and mixed base greases are manufactured by a cooking process which is carried out in large, specially built kettles. These kettles can be described briefly as follows:

1. Direct-fired open kettles with agitators.
2. Steam-jacketed open kettles with agitators.
3. Steam-jacketed closed pressure kettles.

The selection of the proper kettle is determined largely by the qualities needed in the final grease and the manufacturing benefits to be derived.

SODA BASE GREASES

In the manufacture of soda soap greases several methods are used. Fundamentally, they all follow the practice of first placing in the kettle the proper amount of fat. To this are added the caustic soda and perhaps part of the mineral oil. After the soap has been formed and, usually, most of the water cooked out, the remainder of the mineral oil is added slowly and worked into the soap. During saponification the temperature, mixing speeds and pressures, in those cases where pressures are involved, are all rigidly controlled. Manufacturing temperatures are often in excess of 300 F.

WHERE USED

Soda soap greases are commonly used as "ball and roller bearing" greases. They are suitable for high speeds and high temperatures. In general, they are not adapted for use in the presence of excessive amounts of water where detrimental emulsification may occur. However, certain of the sodium soap greases have been developed recently to counteract excessive moisture conditions. They are used widely and recommended for all types of anti-friction bearings, and for plain bearings subject to temperatures in excess of 175 F. These greases incorporate various lubricating oils ranging from light spindle oils to cylinder stocks depending upon their intended field of service.

It should be noted that a mechanical operation called "milling" is often employed in the manufacture of soda soap greases to make more smooth the texture and shorten the natural grease fibre. A grease in service is subject to mechanical action very similar to milling. Therefore, instead of requiring the bearing to perform this mechanical operation of milling before the grease can be fully efficient, the grease is milled so that when it is used, it is ready immediately for effective lubrication.

MILLING THE GREASE

There are various methods known for milling grease but all consist essentially of working the cold grease to break down the natural fibrous structure so that the grease as applied will be capable of instantly lubricating the bearing. One of the most efficient methods for milling or "working" grease is to circulate the grease by means of a heavy duty geared pump through a specially designed filter screen.

As in the case of the soda soap greases many methods are used in making lime base or calcium soap greases. In general, the caustic lime and fat are saponified and to the resultant soap is added the proper amount of oil necessary to obtain the desired consistency. The cooking temperatures are in general lower than those used in the manufacturing of soda soap greases.

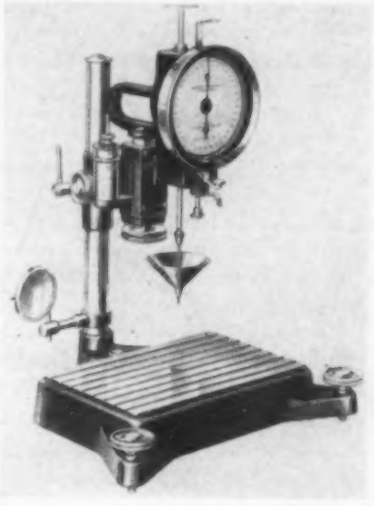


Figure 1 — Universal model penetrometer with adjustable head for determining penetration or consistency greases.

Calcium soap greases are commonly used as general purpose lubricants. They find wide application in compression grease cups and pressure fittings for plain bearings in industrial plants. They are not satisfactory where operating temperatures exceed 175 F or where speeds are in excess of 2000 rpm. Centrifugal force incident to high speeds and also high temperatures tend to separate the mineral oil from the soap base. Calcium soap greases may incorporate oils ranging from light spindle to heavy cylinder oils depending upon the uses for which they are intended. Their outstanding qualities are water repellency and the ability to shear more readily than soda soap greases of the same consistency.

ALUMINUM BASE GREASES

The aluminum soap used in these greases is usually prepared by the reaction of a water-soluble alkaline soap on a solution of aluminum sulphate. The precipitated soap is washed free of impurities, then dried and dissolved in the mineral oil.

The texture, consistency and stability of aluminum soap greases are largely dependent on the rate of cooling and the milling process to which the greases are subjected.

Aluminum base greases combine certain of the advantages of both lime and soda base greases. They are water repellent and withstand somewhat higher temperatures than calcium soap greases. They do not separate readily when agitated or when used in centralized greasing systems. They find wide application where non-spattering and adhesive type lubricants are required or where shock loads prevail.

LEAD BASE GREASES

The lead soap is generally prepared by the action of lead oxide (PbO), reacting on fatty acids. The soap is then washed with hot water to remove impurities and is then thoroughly dried. The lead soap is then dissolved in the correct amount of mineral oil.

These lubricants, in combination with other materials, are usually classified as "extreme pressure," since they have the capacity to resist very high pressures. Lead base greases are often used as a base for manufacturing extreme pressure greases for use in hypoid gear type differentials where extreme rubbing pressures are encountered.

MIXED BASE GREASES

The methods used in making mixed base greases can be summarized as follows:

1. Preparing each soap separately, mixing them together and then adding the lubricating oil.
2. Simultaneous preparation of both soaps in the same kettle and adding oil in the usual way.

These mixed base greases are used where conditions require characteristics beyond the range of a single base soap. Mixed base greases combine to a certain degree the characteristics of the individual soaps used in the admixture. For instance, under conditions requiring the use of a soda soap grease in the presence of excessive amounts of water, the addition of a calcium soap may improve the water repellent characteristics of the resultant grease.

SOLID FILLERS

Graphite, talc, mica, soapstone, wool, cotton yarn and horsehair are sometimes used as grease fillers. These are used where some unusual mechanical condition requires the utilization of the natural qualities inherent in these materials. They are not in general use but are used occasionally. As engineering design of mechanical equipment improves, these fillers are being eliminated rapidly as constituents of greases.

While on the subject of fillers, it is of interest to note that certain chemical compounds are sometimes added to greases to provide specialized qualities in the finished products. These substances are generally of complex chemical structure and are known usually by trade names. Certain of these additives provide qualities such as additional film strength, resistance to moisture or other contaminants, greater adhesiveness, cohesiveness, and resistance to deterioration.

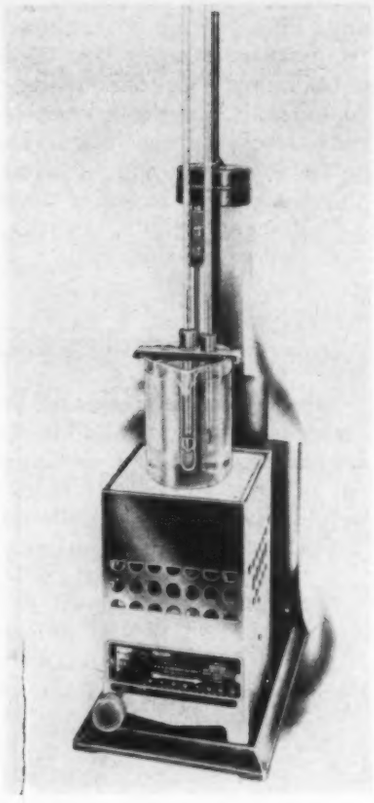


Figure 2—A.S.T.M. grease dropping point apparatus for determining dropping or melting point of greases.

GREASE TESTING

To maintain standards and insure uniformity of grease, certain control tests are used. These tests are conducted on standardized test instruments. All factors such as temperature and speed are controlled rigidly to insure that the same test results can be obtained in all laboratories and in all sections of the country.

There are a large number of tests and test instruments for determining and insuring the maintenance of grease qualities. However, certain of these tests are either in the experimental stage or have not received as yet universal acceptance. The test methods about to be described are accepted procedures, universally recognized and readily duplicated.

CONSISTENCY OR PENETRATION

The accepted consistency or penetration test is a tentative standard of the American Society for Testing Materials known as "A. S. T. M. Designation: D217-38T." It consists of measuring with a penetrometer (Figure 1) the consistency or hardness of a grease. This quality is referred to either as the "worked consistency" or "unworked consistency." The "worked consistency" is the consistency determined after the grease has been subjected to sixty double strokes of the plunger

in the grease worker. The "unworked consistency" of a grease is, as the name suggests, the consistency determined without first subjecting the grease to the action of the grease worker.

The test is conducted by placing in a standard size container, a measured amount of grease. This container is placed on the penetrometer table and the cone of the instrument lowered until the tip just touches the top surface of the sample. The plunger actuating the cone is then released and rests free on the grease for five seconds. The depth to which the cone sinks into the grease is then read from a graduated scale. The harder the grease, the lower the reading. The softer the grease, the higher the reading. During this test all variables such as temperatures, air pockets in the grease, etc., are strictly controlled.

GREASE NUMBERS

Greases falling within certain readings are classified in accordance with numbers established by the National Lubricating Grease Institute. These are as follows:

N. L. G. I. No.	Consistency or Penetration
0	355-385
1	310-340
2	265-295
3	220-250
4	175-205
5	130-160

Certain greases such as gear lubricants and semi-fluid greases, are not tested in this way because their consistency is too light for accurate readings. There is a method using a lighter weight cone now being used by laboratories for determining consistencies of greases lighter than N. L. G. I. No. 0. However, this method is not yet well enough established in general use to be accepted as a recognized standard.

Most of the commonly used greases are now classified according to the above N. L. G. I. numbers. However, there are still made throughout the oil industry, greases using numbers which were established before the N. L. G. I. range became generally used. These numbers have no specific relation to N. L. G. I. penetration or consistency, but are arbitrary designations assigned by individual manufacturers.

MELTING OR DROPPING POINT

Dropping point or melting point is determined using the American Society of Testing Materials' test method "A. S. T. M. Designation: D566-42." The test determines the temperature at which a grease passes from a semi-solid to a liquid state. The test instrument used (Figure 2) consists of a chromium plated brass cup with an orifice in the bottom. Into this cup is placed a measured amount of grease. This cup is then placed in a test tube and a thermometer registers the exact temperature of the grease. The apparatus is then placed in an oil bath. The temperature is raised gradually until a drop of the grease drips from the orifice of the cup. The temperature is recorded when this occurs and is known as the "dropping point" or "melting point" of the grease.

Melting points or dropping points vary considerably depending on what test method is used. The above described test method is the generally accepted standard. When reference is made to melting point or dropping point, it is advisable to state the test method used.

GREASE ANALYSIS

The methods of analysis for determining the constituents of a grease have been standardized under the American Society for Testing Materials "A. S. T. M. Designation D128-40." By using the outlined methods, the percentage of fillers and ash, soap bases, soap, fat, water, excess alkali or acid, petroleum products and unsaponifiable matter can be determined. The procedures are complicated and involve both chemical and physical tests. These tests have value in identifying unknown greases and determining the conformity of any grease to established operational or purchasing standards.

MECHANICAL TESTS

In addition to meeting the requirements of the physical and chemical tests outlined above, greases should in addition pass established mechanical tests. These mechanical tests are a laboratory proof that the grease is properly made and functionally correct. Where possible, the actual machine or machines for which the grease is designed, are used as test instruments. Where not possible, as is the case with large machinery, smaller units are constructed and the test results correlated with actual service results on the larger units.

A typical and well known example of mechanical testing is the low temperature test of automotive greases. For the purpose of the test, the entire automotive vehicle is driven into the test room. This room is constructed specially for the maintenance of low temperatures. All parts are lubricated with the proper greases and the room temperature then lowered to below the minimum encountered service temperature of the unit. This temperature is maintained for eight hours before the actual test work begins in order to allow sufficient time for the greases to become thoroughly cooled.

The test is then started and each bearing and part checked accurately with scientific instruments to make certain that all operating points are receiving a proper and efficient quantity of the lubricating grease. Unless each lubricant performs in accordance with rigid standards it is considered unsuitable for use and is rejected.

Laboratory tests, no matter how accurate or how closely they approximate service conditions, are never considered as final. Each grease must, in addition, be tested in service and be subjected to all known conditions for which it is designed. Only then is the grease considered acceptable for sale.

Brush Engineering

. . . . developments in industrial power brushes have aided greatly in meeting many production problems . . . . the application of power brushing to modern production has advanced to an exact engineering status . . . .

by G. O. ROWLAND
BRUSH DIVISION
THE OSBORN MANUFACTURING COMPANY
CLEVELAND, OHIO

▲ THAT power brushes are indispensable in helping metal manufacturing and metal working concerns meet current demands is strikingly emphasized in an analysis of recent advancements and typical brushing applications made by our company.

Probably the greatest single factor that has resulted in the increased use of power brushes has been the recent intensive "brush engineering" research conducted by factory and field technicians to improve the performance and increase the usefulness of power brushing equipment. Progress has been so marked in this respect that manufacturers, fabricators and processors depend upon today's brushing techniques for better surface finishing results.

As practically every metal part that goes into a production line, whether stamped, sawed, punched, cast, welded or machined, has rough surfaces or edges that must be smooth finished, it is obvious why a thorough study of each application must be made to insure the most efficient results.

Iron and steel mills, in addition to other industries, use brushes in almost every division of their plants to clean metal, to remove burrs and rough edges and to maintain machinery and equipment. Several of the newer applications for this work have increased efficiency many times over.

One of the applications in which the use of brushes has received considerable thought and study, is in the cleaning of surfaces of strip prior to plating. The successful application of electrodeposited coatings requires that the surface to be plated be free from dirt and grease. Spiral type rotary brushes, filled with one of the several brush materials available, have proven very successful for this type of cleaning.

Spiral type brushes filled with a suitable grade of horse hair, for example, have been recommended for use in tin line branning machines. This type of service, while relatively light, is, nevertheless, important and the proper application of suitable brushes is very desirable from an operating standpoint.

Figure 1 — Flat surface welds are effectively cleaned with this double row cup type brush. It is 6 in. in diameter with a 5/8 in. arbor hole.

While the most generally used brush material is a fibre known as tampico, brushes have been made for specific applications, which require the use of other material such as stainless steel, nickel silver, or carbon steel wire, nylon, and special types of natural fibres. A specially-treated and woven cord has also been developed for use in cleaning lines where the removal of traces of carbon smut is necessary.

Wire filled brushes either spiral or sectional type, are also used for removing scale from sheets or strip. In order to provide brushes of maximum efficiency and life, engineers have developed special specifications for the wire used in these brushes.

Some of the important factors uncovered by "brush engineering" analysis include the predetermining of proper speed of rotation, the type of brush chosen from the thousands of varieties listed in the company's catalogue, the material from which it is made (wire, fibre or cord), the diameter of the brush, the compound sometimes applied to aid the brushing action and the way in which the article is handled during the brushing operation.

A few of the typical applications of power brushing disclosed by the analysis and which are applicable in many industries, include the cleaning of deflamed surfaces of steel plates where work was speeded up 100 per cent.

This development involved the designing of a double-row cup brush as shown in Figure 1.

Designed to give exceptionally long service when used with heavy-duty high-speed tools, the cup is six inches in diameter containing .020 S.A. wire, and is operated on an air tool at 3,000 to 4,200 revolutions per minute, with the speed regulated by valve on the tool.

Another job consisted of the cleaning of built-up welds in narrow grooves. This work was greatly facilitated by the application of a disc center section brushing wheel, 6 inches in diameter and $\frac{5}{8}$-in. thick, with a $\frac{1}{2}$-in. arbor hole. The .029 wire in this brush is twisted into tufts. The brush is run at 4,000 to 6,000 revolutions per minute on an electric or air tool.

The highly publicized aircraft industry has benefitted tremendously from the advancements in power brushing.

By rounding corners, blending surfaces and removing burrs and tool marks on highly stressed parts, brushing wheels eliminate stress concentration points where dangerous fractures may originate and possibly lead a plane to disaster. On a crankshaft alone there may be as many as 158 possible locations for points of stress concentration.

In addition to increasing the resistance of highly stressed parts to fracture, brushing wheels are helping airplane engine builders achieve closer tolerance and construct airplanes with greater operating efficiency. Certain brushing wheels enhance the workability of precisely machined parts, by improving their friction characteristic even to the point of preparing surfaces to hold lubrication.

One of the most meticulous jobs in the brushing of engine parts was the elimination of sharp corners and the blending of surfaces on the ball ends of push rods. Each rod is about as large as the end of your little finger. Into the center of the ball is drilled an oil hole about $\frac{1}{16}$ in. in diameter.

The drill always leaves a sharp corner or burr, and if the corner is not carefully radiused and the surfaces blended, the ball end may become the site of a stress concentration point, where a fracture originates.

Before we studied the job, the work of finishing this vital engine part was done laboriously and slowly by hand with the use of powdered emery and a cloth. This method was not uniformly successful for it often distorted the shape of the ball end, and the part had to be rejected.

It was found that this job could be quickly and effectively done with a radial brushing wheel of tampico fibre.

The push rod end, when applied to the brush, is placed inside a cup on the end of a wooden or metal fixture. While the brush revolves against the metal at a speed of 2,400 revolutions per minute, the push rod end rotates. Careful profilometer tests show that the surface accuracy is kept within four millionths of an inch. By this method about five pieces are finished in a minute.

Brushes of tampico fibre are being given many important jobs in the manufacture of aircraft engines. The fibres of the brush reach areas that cannot adequately be reached by other methods. In the manufacture of very small parts of machines they are most helpful.

More than 100 new kinds of industrial brushes such as one made of nylon fibre for cleaning bombsights, have been perfected. Engineering advisory service on the design of both the brushes and the brushing machines is now based on many years of experience in all phases of the steel industry.

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"We Reduced Production Delays By Installing BUSS Super-Lag FUSES. Now We Use Them Exclusively"

Reports **M. J. HYMEL,**
Purchasing Agent,
Service Foundry, Inc.,
New Orleans, La.

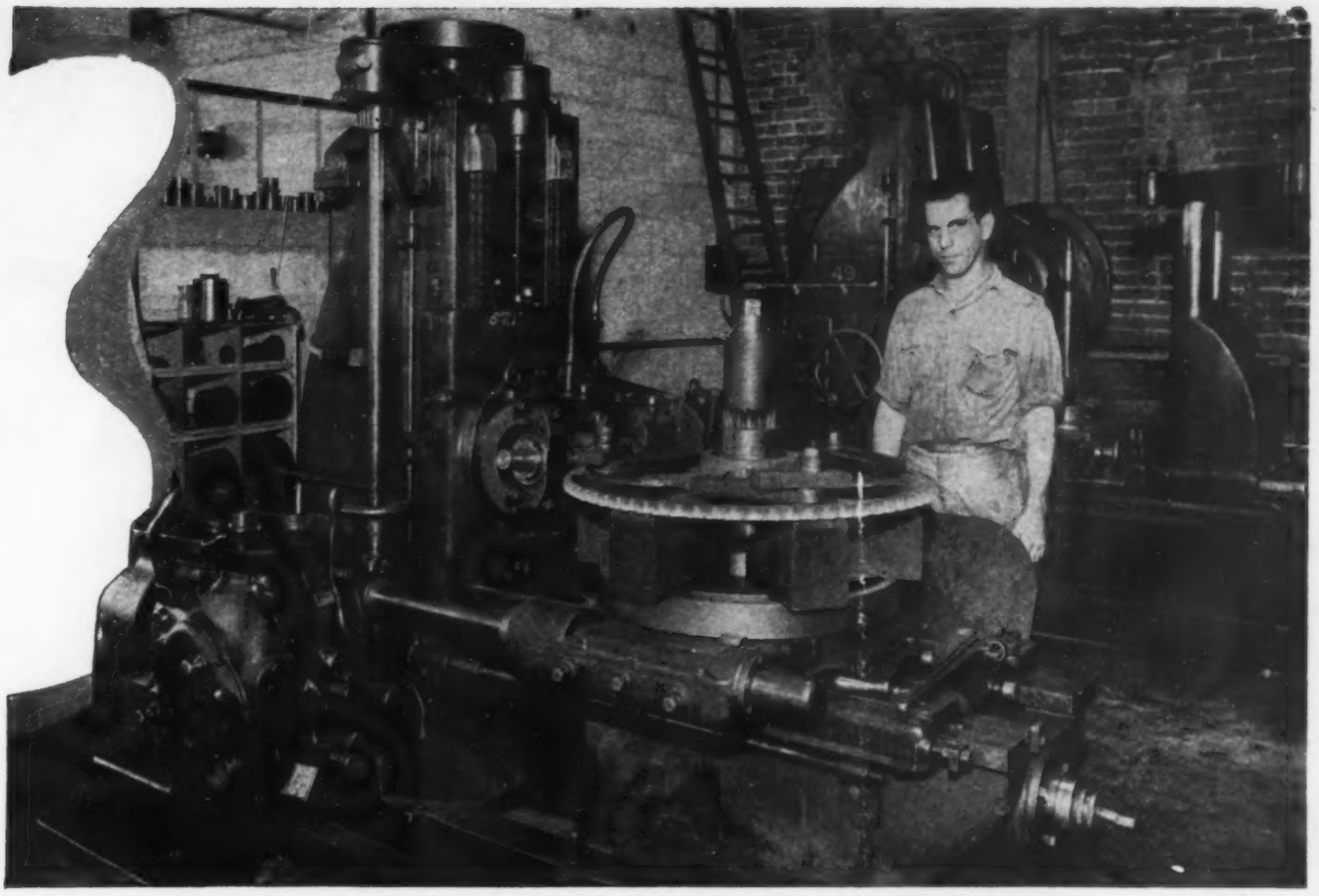
"About two years ago," says Mr. Hymel, "our electric motors were frequently shut down because fuses were blowing on motor starting loads. These shutdowns were costly—causing interruptions that cut production, disrupted scheduling, and made it difficult to meet delivery promises.

"A wholesaler's salesman had the right answer to our problem when he recommended that we discard our old fuses and use only Buss Super-Lag fuses. Since that time we have completely eliminated fuse blows due to motor starting loads. This convinced us. We have standardized on BUSS, because they have eliminated our troubles."

Why BUSS Fuses Don't Blow Needlessly

10 FEATURES in the design of the FUSE-CASE help make it possible. *and* ***The* SUPER-LAG** development in the FUSE-LINK completes the job.

★★★ **BUSS**



Gear Hobbing Machine in Service Foundry, Inc.

Here is another outstanding example that demonstrates how Buss Super-Lag fuses are helping to keep production running smoothly, how they reduce lost man-hours, and save trouble and grief for electricians and maintenance men.

If you have a problem similar to the one at Service Foundry, Inc., doesn't this example indicate how you can profit by the use of Buss Super-Lag fuses?

Buss fuses require no maintenance or periodic inspection. They don't open needlessly. If one opens, you can be sure some condition needs correction. When one opens, it requires less than 45 seconds to renew with an inexpensive link.

Why BUSS Fuses greatly reduce or entirely prevent needless blows

The fuse case is designed to insure good contact on the link, even when the fuse is renewed by an inexperienced person—and it is so designed that vibration or heavy overloads or the constant heating and cooling of the fuse will not permit poor contact to develop. Thus excessive heating, which causes fuses to blow needlessly, is prevented.

The fuse link used is the famous "BUSS Super-Lag." It has lag-plates attached to it. These give it a time-lag so long that it will reduce to an extent not possible with any other renewable fuse, the number of shutdowns caused by needless fuse blows.

Prevent future trouble in your plant—by doing this today

Pass the word along that all purchase records dealing with circuit protective devices should be immediately changed to call for BUSS Super-Lag Renewable fuses. Then, as fuses are replaced or new installations made, your plant will automatically get the benefit of the carefree, trouble-proof protection that BUSS Super-Lag fuses afford.

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36" wide belt conveyor equipped with Link-Belt type "70" troughing idlers and type "71" return idlers, handling mine run ore from mine ore bin to vibrating grizzly and picking belt at the rate of 100 T.P.H. Conveyor is operated by a Link-Belt Motorized Speed Reducer and Silverlink Roller Chain Drive.

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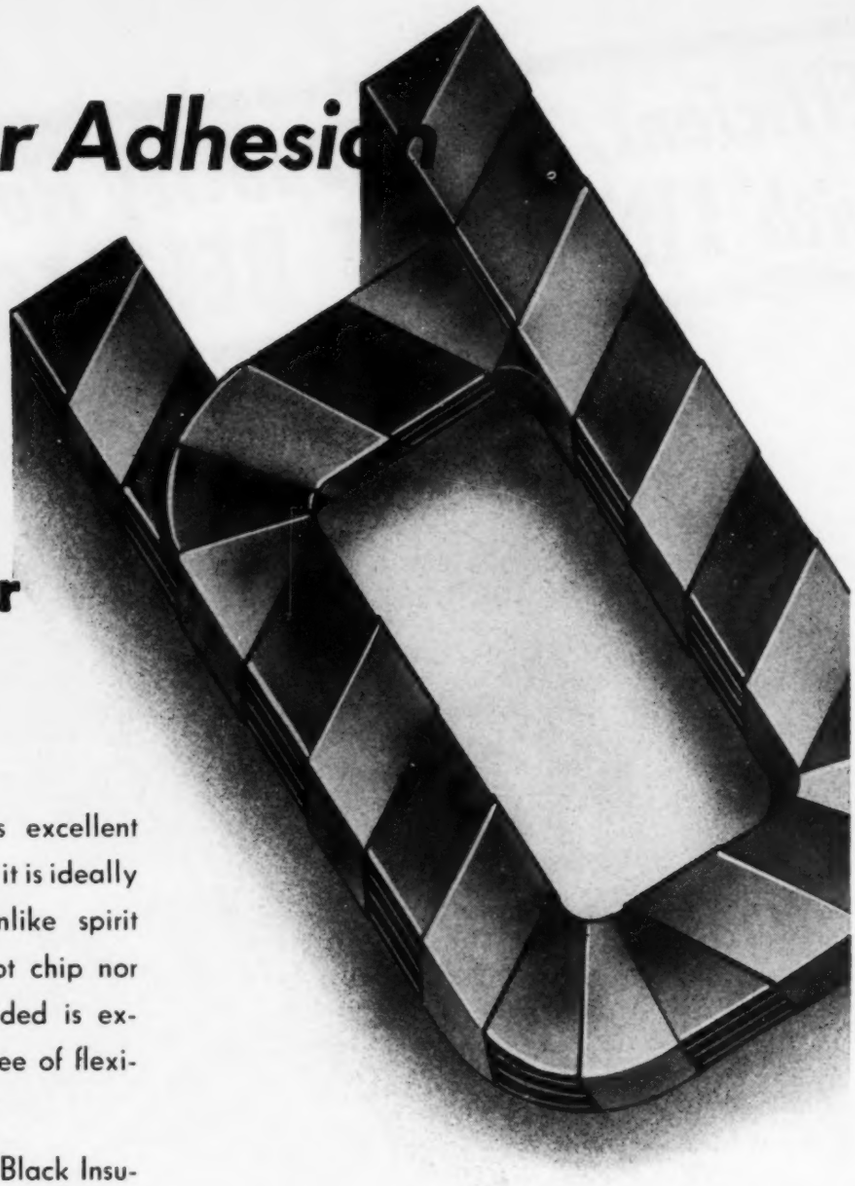

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The tough, glossy film of No. 27 Black Insulator affords excellent resistance to abrasive particles. It provides a higher degree of waterproofness than spirit varnishes and is absolutely oilproof.

Supplied at a brushing consistency, No. 27 Black Insulator should be reduced 25% for spray gun application. The proper thinner for this grade is DOLPH'S No. 27-T.

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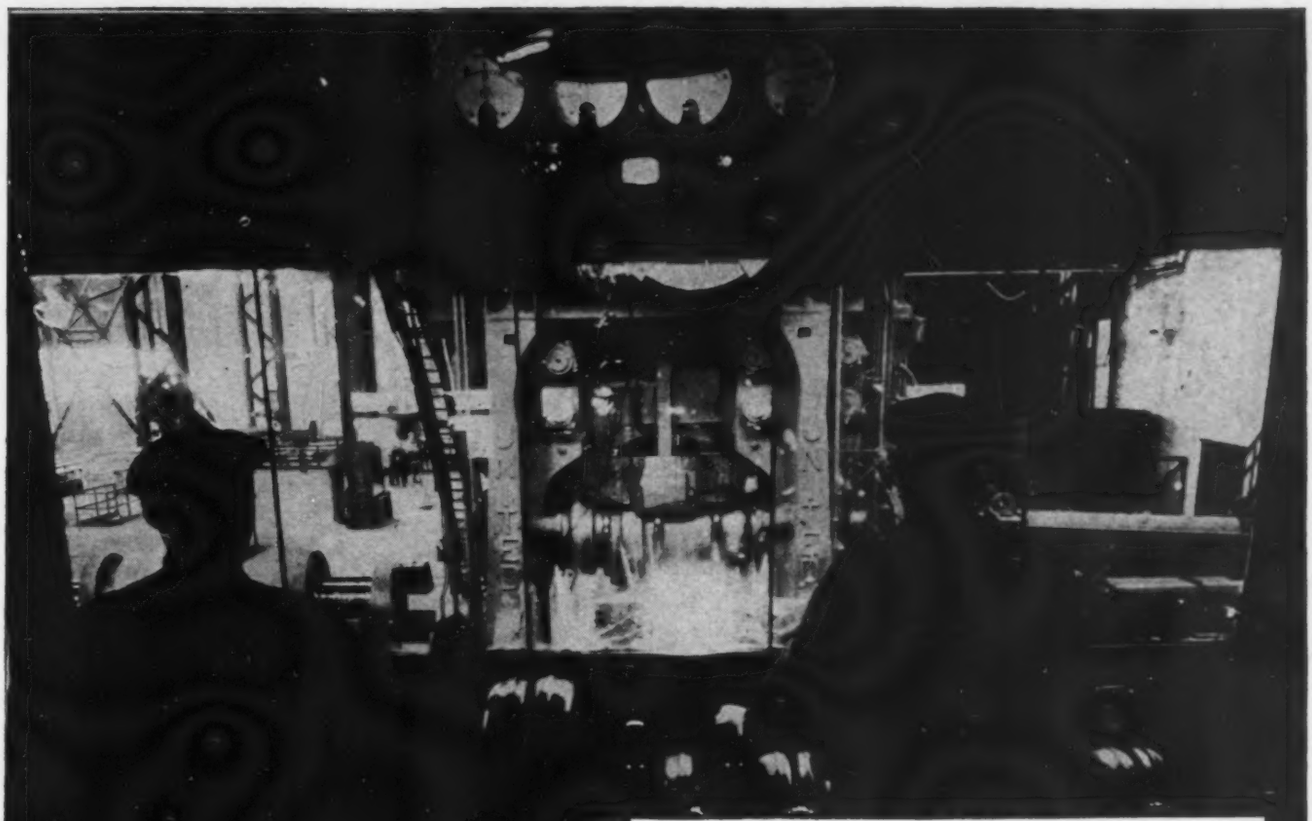

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High above the roaring rolls, toying with tons of pressure, he shapes the blazing billets with a finger-flick—as another artist might mold clay.

No need to preach the doctrine of dependability in the parts that take the punishment. He *knows* that N-B-M Steel Mill Bearings and Castings take the worst he can inflict—and still sustain the rhythm of his rolls.

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"For our **HEAVIEST** loads we use LIGHTWEIGHT chain!"

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Monel link chain is available in standard sizes from ¼" to 1¼". A complete line of chain accessories such as hooks, special lifting links, U bolts and open links are regularly supplied by Youngstown Welding Engineering Co., Youngstown, Ohio. Forged sprocket chain is also available.

Two 19-foot Monel sling chains in use. They handle 4 to 5 tons of steel tubing at a time . . . in sulfuric acid at 180° F.

Which would you consider safer . . . ¾" chain that had already seen 6 years' service . . . or 1¼" chain only 9 months old?

The newer, heavier chain, you say? Read what this user reports:

> *". . . the 1¼" cast acid-resisting chain began to need repairs after nine months of service. So—in spite of the great difference in size—whenever we have particularly severe loads, we use the ¾" Monel chain. Although it is over six years old, we find it reliable and not subject to sudden breaks, as is the case with the cast acid-resisting chain."*

Monel pickling chain is made from hot-rolled Monel rod, formed in specially designed dies. The links are welded. Made in this way it is much stronger and tougher than the cast acid-resisting type.

Even *more* important, Monel chain resists corrosion by pickling acids . . . it *retains* its strength and thus provides years of trouble-free, economical service. The same is true of crates, baskets, tie-rods and other Monel pickling equipment.

Practical, usable information which can help you increase pickling room efficiency is contained in the booklet, "Safety and Service with Monel Chain." Write for *your* copy *now* . . . before it slips your mind.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET, NEW YORK 5, N. Y.

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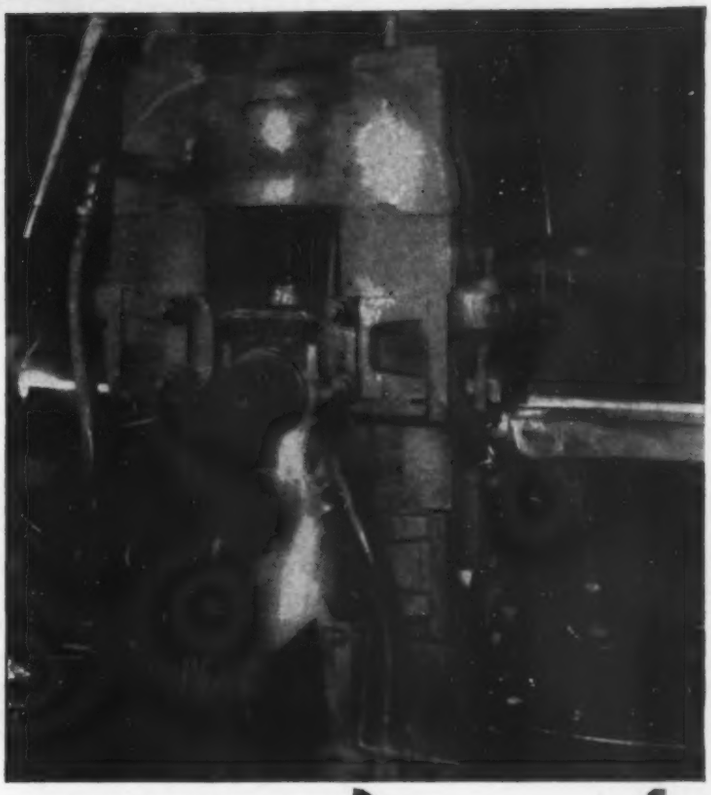
A·B·K Laminated Plastic Bearings are made to a tested formula in one of the most modern plants in America. They are furnished to size, ready to install without extra machining.

Developed by American Brakeblok engineers to provide an unusually low coefficient of friction, A·B·K Laminated Plastic Bearings have shown extensive savings in power consumption when used on rod, merchant, blooming and other steel mills.

In addition to power savings, A·B·K Bearings have provided increased production up to 20 times the tonnage as compared with metal bearings.

The research and engineering facilities that created this dependable, long lasting material are available for your individual needs. Phone, write or wire American Brakeblok Division, 4600 Merritt Avenue, Detroit 9, Michigan.

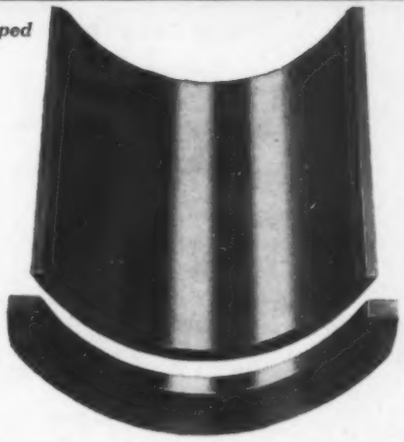


14-inch Roughing Mill equipped with A·B·K Bearings.

A·B·K Patented Reinforced Edge Slipper Bearing. Made ready to install to your blueprints.

Phantom view of A·B·K Patented Reinforced Edge Slipper Bearing.

A·B·K Laminated Plastic Roll Neck Bearing with separate thrust collar.



Industrial and Marine Uses
A·B·K Laminated Plastics

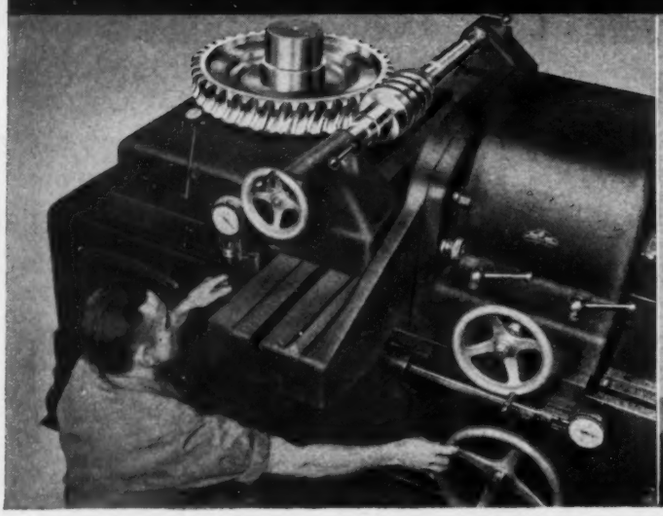
Textile Mills	Pintle Bearings
Rubber Mills	Marine Stern Tube Bearings
Steel Mills	Rudder Bearings
Paper Mills	Engine Mounts
Industrial Truck Wheels	Pump Valve Discs

American Brakeblok

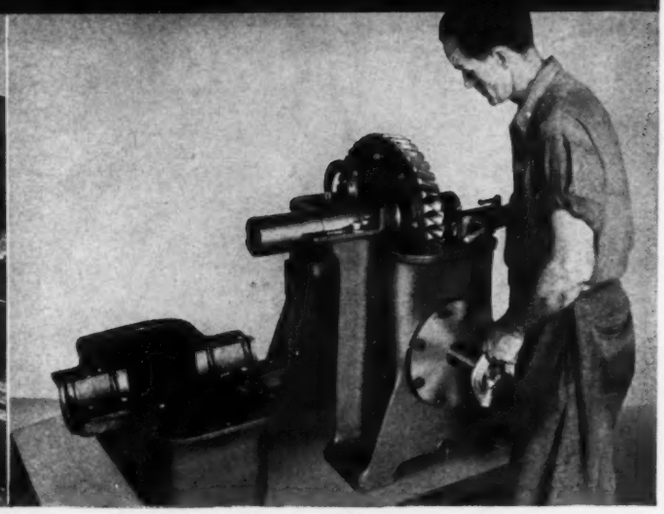
TRADE MARK REG. U.S. PAT. OFF.

DIVISION OF AMERICAN Brake Shoe COMPANY

CHECKED for TOOTH CONTACT



1.—Checking tooth contact with worm and gear located at exact center distances, checked to within 1/10,000th of an inch.



2.— Checking tooth contact by means of "bearing blue" after assembly.

BOTH BEFORE and AFTER ASSEMBLY

Before assembly, every De Laval Worm Gear is tested on the machine shown at the left, in which it is accurately mounted with the center line of the gear and the center line of the worm correctly spaced and at true right angles. Under these conditions the tooth contact is observed and the back lash accurately measured.

After assembly in the gear case, tooth contact is re-checked by means of bearing blue to assure correct adjustment. Such checking and holding center distances within close limits assures satisfactory operation of De Laval Worm Gear Speed Reducers, and facilitates installation when De Laval Worm and Gear sets are purchased for use in other machinery.

Specifications alone do not make a worm gear.

1147

TURBINES · HELICAL GEARS and WORM GEAR SPEED REDUCERS CENTRIFUGAL PUMPS · CENTRIFUGAL BLOWERS and COMPRESSORS · IMO OIL PUMPS

WORM GEAR DIVISION

DE LAVAL

STEAM TURBINE COMPANY · TRENTON 2, NEW JERSEY

SALES OFFICES: ATLANTA · BOSTON · CHARLOTTE · CHICAGO · CLEVELAND · DENVER DETROIT · DULUTH · EDMONTON · GREAT FALLS · HAVANA · HELENA · HOUSTON KANSAS CITY · LOS ANGELES · MONTREAL NEW ORLEANS · NEW YORK · PHILADELPHIA PITTSBURGH · ROCHESTER · ST. PAUL · SALT LAKE CITY · SAN FRANCISCO · SEATTLE TORONTO · TULSA · VANCOUVER · WASHINGTON, D. C. · WINNIPEG

Want a marketing edge?

Here is a vertical precision mill that rolls hot rounds within cold round tolerances. It's the kind of equipment that gives you an important sales edge in tomorrow's business battle. It's another example of the progressive M-H attitude toward customer's production problems. Mackintosh-Hemphill in their particular sphere of metallurgy, engineering and manufacturing have led the world for 140 years in *advanced industrial thinking*. They offer you a cooperative service that is constantly helping others to find new ways to greater sales and profits through the installation of better heavy duty equipment.

MACKINTOSH-HEMPHILL CO., Pittsburgh & Midland, Penna. · **Makers of the rolls with the red wabblers**

OTHER PRODUCTS—*Rolling Machinery . . . Shape Straighteners . . . Strip Coilers . . . Shears . . . Levellers . . . Pinions . . . Special Equipment . . . Iron Steel Castings . . . The NEW Abramsen Straightener . . . Improved Johnston Patented Corrugated Cinder Pots and Supports . . . Heavy Duty Engine Lathes.*

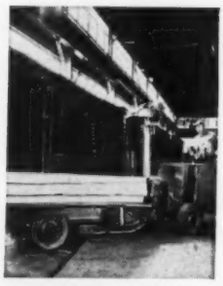
Is your problem one of HANDLING SHEET MATERIALS?

The handling of materials in sheet form—particularly if sheets are large and unwieldy, can best be accomplished by power industrial trucks. Case histories listed below, taken from the new Baker Catalog and showing how Baker Trucks are efficiently performing this operation for others, may suggest the answer to your problem.

★ ★ ★

Paper mills, box board manufacturers and other paper converters are using Baker Trucks to good advantage for transporting, storing, loading and unloading paper in large packages of sheets and rolls. Often sheets are strapped to skids at the mill, and these "unit packages" are kept intact until they reach their destination. (Left) One mill reports savings up to 80% in paper handling costs.

Baker Fork Trucks are used extensively to eliminate individual handling of sheet steel in steel mills and fabricating plants. In addition to saving man hours and speeding movement, these trucks conserve warehouse space by tiering skid loads of sheets two and three high. (Right) Savings in sheet steel handling run as high as 87%.



To meet the demand for an efficient method of loading and unloading the large sheets of steel used for automobile bodies, Baker engineers developed the Baker Articulated Sheet Handler. This truck handles sheets up to 48" x 144" in packages weighing up to ten tons, loading 200 tons per hour at gross savings of $4.30 per ton. (Left)

A leading producer of wall board for prefabricated homes found Baker Low-Lift Trucks ideal for handling large quantities of 8 x 14 ft. panels. Besides effecting substantial savings in handling costs, this company conserves manpower and minimizes damage to material transported. (Right)

The world's largest manufacturer of domestic ranges uses a fleet of 8 Baker Hy-Lift Trucks for handling the tons of steel sheets consumed daily. On one operation, (illustrated, left) carrying sheets from shearing department to stamping presses, costs were reduced from 14c to 1.6c per ton. Overall savings in handling costs were reduced 75% over former methods.

A Baker Fork Truck cut time required for handling rubber sheets 50% at a large rubber plant. Actual savings had paid for the truck eight months after it was placed in service. The heavy rubber sheets are placed on pallets, facilitating transportation, storage and car loading. (Right)

★ ★ ★

If you have a material handling problem and are looking for the best answer, the Baker Material Handling Engineer nearest you will gladly help you. Or write us direct.

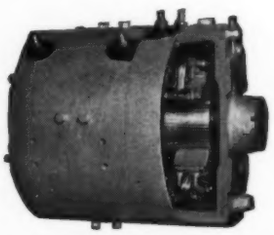
BAKER INDUSTRIAL TRUCK DIVISION *of The Baker-Raulang Company*

2166 West 25th Street • Cleveland, Ohio

In Canada: Railway and Power Engineering Corporation, Ltd.

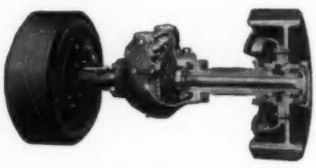
LOOK AT THESE BAKER CONSTRUCTION FEATURES BEFORE YOU BUY AN INDUSTRIAL TRUCK

Every part of every Baker Truck has been especially designed and developed for its specific function. Many Baker features are exclusive, others, pioneered by Baker are now standard in the industry.



BAKER-BUILT MOTORS

All motors are designed and built by Baker to give greatest efficiency for their specific function. Truck motors develop highest H. P. and contain more copper and iron than any others of the same size. Top efficiency is assured by ground fit between field ring and poles, heavy forged commutator bars and large brush surface. Brushes and armature shafts are easily accessible for adjustment or replacement.



BAKER POWER AXLE

Exclusive Baker design—construction and materials designed for most efficient operation, low maintenance and long life. Hardened alloy steels are used in all vital parts. All bearings, axle shafts and universal joints are dust-protected.

BAKER NO-PLUG CONTROLLER

Promotes easy and safe operation, and protects truck life by compelling drivers to use acceleration steps. Accidental plugging from forward to reverse is prevented. Complete control is by one handle.

WRITE FOR YOUR COPY

Plant and production managers, traffic managers, superintendents, purchasing agents and any others concerned with material handling will find the new Baker Catalog No. 52 a valuable reference.

Baker INDUSTRIAL TRUCKS

FUEL FIGHTS!

Save it with

Johns-Manville INSULATIONS

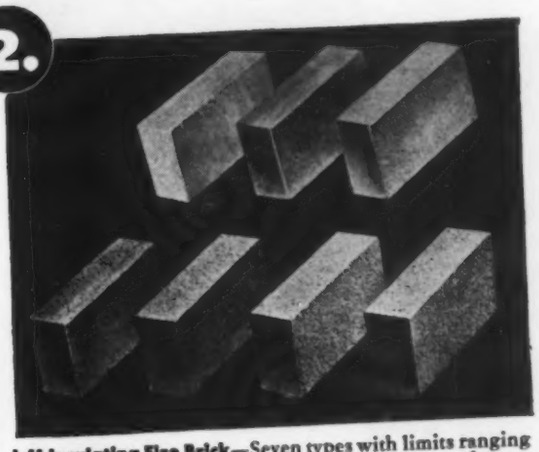
IN addition to saving fuel, these efficient heat-retarding Johns-Manville Insulations help you in other ways, too. For example, they bring about more uniform heat distribution. They make possible more accurate temperature control. In this way the quality of heat-treated products is materially improved.

Every insulating requirement of the iron and steel industry can be efficiently and economically filled with one or more of the many J-M Insulations. At right are three widely used items from the complete J-M line. It will pay to use them wherever possible. For more information write: Johns-Manville, 22 East 40th Street, New York 16, N. Y.

1.

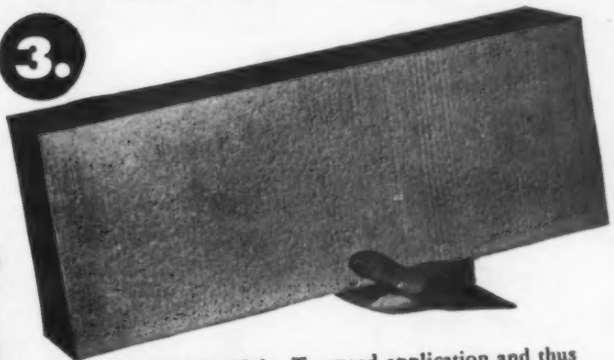
J-M Superex Blocks—Most widely used block insulation for temperatures to 1900° F. For hot-blast stoves, mains, bustle pipes, soaking pits, and above-ground sections of open-hearth regenerators. Thicknesses 1" to 4".

2.



J-M Insulating Fire Brick—Seven types with limits ranging from 1600° F. to 2600° F. Uses include bases of open-hearth furnaces, slag pockets and uptakes, reheating and heat-treating furnaces, upper rings of hot-blast stoves. Furnished in standard fire-brick sizes, shapes.

3.



New Insulating Fireblok—To speed application and thus save many hours' down time, J-M makes available four new Insulating Fireblok. This insulation differs from Insulating Fire Brick only in size, being about 5 times larger.

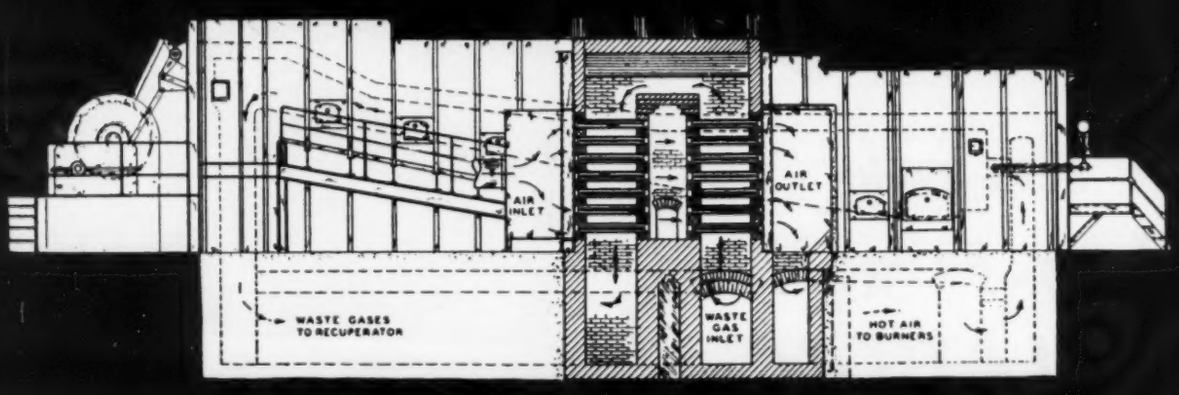
JOHNS-MANVILLE JM PRODUCTS

Johns-Manville

INDUSTRIAL INSULATIONS

FOR EVERY TEMPERATURE . . . FOR EVERY SERVICE

14 LARGEST STEEL MILLS USE *Fitch Recuperators* in 58 Continuous Re-Heating Furnaces



Two Pass Recuperator on Continuous Furnace in Rod Mill.

TYPES OF MILLS SERVED

- STRIP MILLS
- STRUCTURAL MILLS
- WIRE MILLS
- ROD MILLS
- SLAB MILLS
- BILLET MILLS
- TUBE MILLS

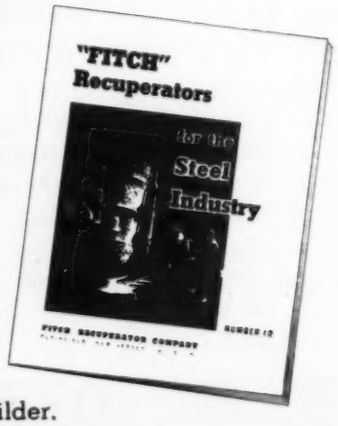
In one huge plant where two furnaces were installed, two different kinds of recuperators, one a Fitch, were used. After four years' operation the Fitch Recuperator proved so much more satisfactory than the other that it was replaced by a second Fitch Recuperator. Subsequently Fitch Recuperators were installed in two more furnaces in this same nationally famous plant.

America's leading steel mills find that with Fitch Recuperators very little time is lost on repairs. The life of the Fitch is extended over a long period of time because of the ease of locating injured tubes and their replacement in a few hours' time.

Our Booklet No. 12 shows plans and elevations on many types of installations. It is free. Write for it today.

FITCH RECUPERATOR COMPANY
Plainfield, N. J.

Write for Booklet



We do not build furnaces—see your furnace builder.

"FITCH" Recuperators

PLAINFIELD, NEW JERSEY, U. S. A.

NEWS SUPPLEMENT December, 1944

Equipment
Personnel
Literature

Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

CARBON EXHAUST FLUES PREVENT CORROSIVE ACTION BY LABORATORY GASES

▲ Amplifying the more widely known uses of carbon and graphite deriving from their chemical resistance to the action of practically all corrosive fluids, a unique application of carbon for controlling corrosive and explosive gases has been developed and installed in the new laboratories building of the St. Lawrence Alloys and Metals, Limited, at Beauharnois, Quebec. This structure, in that it houses offices as well as laboratory, may be typical of many where similar problems are encountered.

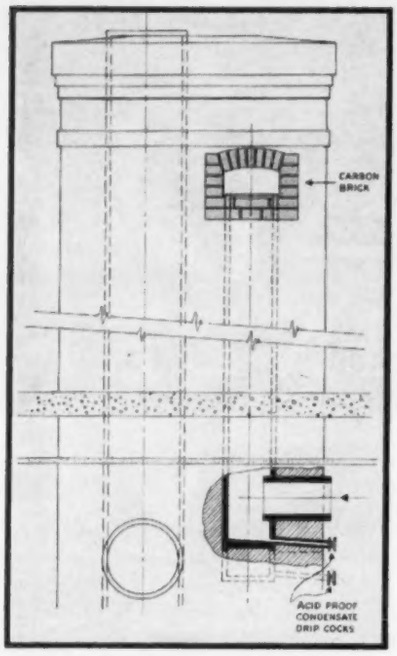
Construction of the new laboratory required that gases from furnaces and testing tables in the basement be dissipated through a brick chimney running up through the center of the building. Due to the corrosive action of the gases on the chimney brick, it was felt that periodic and expensive repair jobs would be required if the gases were exhausted directly through a chimney of the customary brick design. Also, if indiscriminately released, the noxious gases would have constituted an explosion hazard as they contained ammonia, ether fumes, ethyl acetate, chlorine fumes, and hydrochloric, sulphuric, hydrofluoric, nitric and perchloric acids. Not least of the considerations was the desire to eliminate seepage of fumes into the building which could result from disintegration of the ordinary brick.

Two 8 in. i.d. flues of corrosion resistant carbon pipe were built into the chimney to carry the gases and protect the brickwork. Two flues were constructed to keep separate those gases that might produce an explosion if permitted to mix. Metal hoods mounted over the testing tables and furnaces and connected to the horizontal carbon tubes carried ammonia, hydrochloric acid, ether, and ethyl acetate gases into the No. 1 flue. Hydrofluoric, sulphuric, nitric, perchloric acid gases and chlorine fumes were directed into the No. 2 flue.

The gases are exhausted through the flues by mechanical means. To minimize condensation, and a liquid backdrip of acid solutions that might be caused by rain or snowfall in the flue openings at the top of the chimney, roofed chambers with side outlets were built of carbon brick. The bottom of each flue consists of a slanted carbon disc covered with a built-up layer of carbon cement. If there should be condensation and the formation of acid solutions in the bottom of the flues, the solutions will flow out through a small carbon pipe spillway located directly under the inlet section, when the carbon drip-

LARGE FURNACE INSTALLED FOR STRESS RELIEF

Car-type oil-fired stress relieving furnace recently designed and constructed for General American Transportation Corporation at Petroleum, Ohio, by Rust Furnace Company, Pittsburgh, Pennsylvania. The furnace is now in use for heat treating alloy steel pressure vessels.



Carbon flue construction for the dispersal of corrosive gases.

cock is opened. (The parts built of carbon are shown in the shaded sections of the drawing.)

Each of the carbon flues is 31 feet in height and is formed of threaded lengths of carbon pipe. Joints are sealed with a carbonaceous cement with the female threads in the upward position, thus providing an added protection against seepage. According to reports released by St. Lawrence Alloys and Metals, Limited, the exhaust system is highly efficient, and the gas fumes originating in the laboratory are undetectable on the floors above. Carbon materials for the flues were supplied by the National Carbon Company, Inc., and its engineers state that the flues should remain in maintenance-free service for a minimum of 30 years.

IMPROVED DESIGN IN CRANE-TRUCK

▲ The new model L-11C combination crane truck announced by The Elwell Parker Electric Company, Cleveland, Ohio, has improved operating characteristics due to the addition of a separate motor for raising and lowering the boom. In previous models a single motor served to raise and lower both boom and hook, by means of a ratchet boom adjustment which was actuated when the lift hook was pulled up against the boom. By providing a separate motor for each function the operator is given a greater freedom of choice in manipulating the load.

The combination crane truck is a 4-way truck, serving as a lift-truck, a load carrier, crane and tractor. It loads itself either by picking up skid loads with the lift platform, or by lifting heavy parts and placing them on the platform for transport. As a tractor it pulls trailer cars, which may be loaded by means of the crane. The crane may be made available for heavy lifting at points where there are no overhead cranes. This model has a capacity of 6000 pounds on the platform, 2000 pounds on the hook at 42-inch radius and 1000 pounds on the hook at 84-inch radius. It will travel at 6 miles per hour with no load and 5 miles per hour with full load under normal conditions. The platform is deeply flanged to insure rigidity and has three point positive support that assures load stability at all times.

Quick Finding Selector Charts on COUPLINGS for your files . . .

Lovejoy's new simplified Selector Charts quickly put the finger on the exact couplings needed for any duties or conditions. All engineering data, size, weights, etc., right at hand. A great time-saver! Have these Lovejoy Charts in your files for ready reference.

L-R
FLEXIBLE
COUPLINGS

No Shut-Downs for Changing.
Cushions always in sight.
No lubrication ever required.

WIRE OR WRITE

Charts come with complete L-R Catalog

Catalog illustrates and describes L-R Couplings for every duty and requirement — heat, moisture, insulation, inside and outside services, from 1/6 to 2500 h.p. Special couplings also engineered. L-R principle of construction shown with instant adjustment of resilient load cushions to any and every emergency, and elimination of internal friction. Couplings of longest life, practically service-free.

L-R Type "W" for duties to 2500 h.p. at 100 r.p.m. Pat. & Pats. Pend.

L-R Type "WF" bolts directly to flywheel, clutch or drum. Saves 1/3 space. Pat. & Pats. Pend.

LOVEJOY FLEXIBLE COUPLING COMPANY

5016 W. LAKE ST., CHICAGO 44, ILLINOIS *Pittsburgh Office:* **EDW. J. BOYLE CO., 508 GRANT ST.**

CONTACT CONTROLS FOR POTENTIOMETERS

▲ Introduction of electric contact controls for circular chart electronic potentiometers is announced by the Brown Instrument Company. The electric contact controllers will be available in two forms. One will contain a locking-in type relay, designed primarily for electric furnace control. It can also be used for applications involving use of contactors and for processes requiring a differential gap.

The second type, without a relay, is designed for direct control of motorized valves, operation of signalling devices, and for applications requiring a "dead" neutral.

The electric contact control mechanism, according to engineers of the Brown company, Philadelphia precision industrial instrument division of Minneapolis-Honeywell Regulator Company, will be available for circular potentiometer pneumatic controllers. It will serve, when applied to these instruments, as an auxiliary switch for operation of signal lamps and other devices.

THERMOMETER USES ELECTRONIC TUBES

▲ An electronic type resistance thermometer suitable for indicating, recording and controlling temperatures between — 100 F and 1000 F is announced by Bailey Meter Company, 1050 Ivanhoe Road, Cleveland, Ohio. This recorder operates on the highly accurate null balance principle and provides instantaneous balancing action by electronic detection and control. Unbalance of the measuring bridge is detected by electron tubes without the aid of a galvanometer or other moving parts. Reliable performance and accurate calibration over long periods of continuous operation are said to result from this sturdy design.

The recorder-controller indicates, records and controls temperature. A 29 inch indicating scale which circles the chart may be read easily at a distance of 50 feet. The pointer reading coincides with that of the recording pen. Indicating, recording and controlling mechanisms are all driven by the same reversible electric motor which adjusts the slidewire resistance to balance the measuring bridge. This motor is continuously connected to the electronic control unit which in turn is continuously connected to the measuring bridge.

Bailey electronic resistance thermometers may be provided with as many as four recording pens, each one being provided with its own continuously connected electronic control unit and measuring bridge. This feature insures instantaneous response to changes in temperature.

The temperature sensitive element is a platinum resistance wire, wound on a mica form and held between two mica sheets which are clamped by a metal frame. The element is further protected by a well which is permanently installed in the pipe line, furnace wall, duct, or other point of temperature measurement.

Temperature measuring circuits may be arranged to calculate the sum, difference and ratio of temperatures. Calculated results are recorded directly by Bailey electronic type recorders in the form of news instead of history. Much time and labor may be saved by the electronic calculating method as compared with manual calculation from chart records and log sheets.

It's new! It's heavy duty! It's raintight!

Type WMKS **Interlocking** Safety Switch and Plug Receptacle

CONDULET

(CONDULETS are made only by CROUSE-HINDS)

for the control of portable electrical equipment in **both** indoor and outdoor locations.

Safety. Positive interlock prevents opening the case or withdrawing the plug unless the switch is "off". Switch can't be turned "on" unless the case is closed and the plug fully inserted.

Switches. Motor circuit switch. Quick make and break. Double break, reinforced, positive pressure-type blade and jaw construction. Positive pressure fuse clips. Combination solder or solderless wire lugs 2 or 3-pole fusible.

Plug Receptacles. Style I is grounded through the shell. It will take the plugs used with the former Type MKS of the same rating. Style II is grounded through an extra pole and the shell. An eyebolt and wingnut prevents accidental withdrawal of the plug when the switch is open.

Cast metal case. Strong and durable. Four sturdy mounting feet. Many possible threaded hub arrangements for both vertical and horizontal conduit. Cover may be padlocked to prevent unauthorized entry. Operating handle may be padlocked "on" or "off".

Threaded operating shaft. Bearings permanently lubricated to resist corrosion and prevent the entrance of dust and moisture.

Horse-power ratings. 2 through 50 H. P.

30, 60, 100 or 200-ampere. 230 or 575 Volts A. C.

Listed in Condulet Catalog No. 2500, Section 50, Pages 21 and 22

Type WMKS Interlocking Safety Switch and Receptacle Condulet with Type DP Interlocking Plug

A Nationwide Distribution Through Electrical Wholesalers

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CONDULETS · TRAFFIC SIGNALS · AIRPORT LIGHTING · FLOODLIGHTS

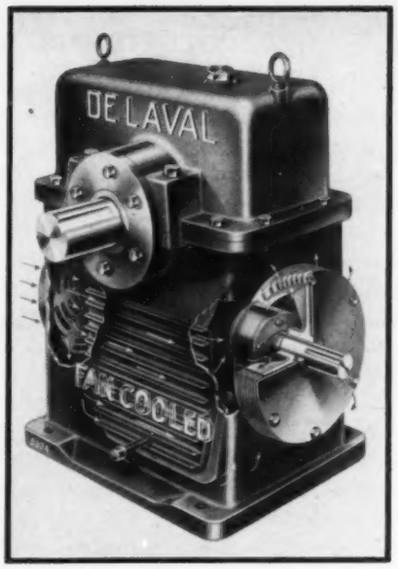
FAN-COOLING DOUBLES CAPACITY OF WORM GEAR SPEED REDUCERS

▲ Heretofore, the capacity of worm gear speed reducers, operating at high speeds, has been limited not by the strength of materials, but by the ability of the casing to liberate heat which otherwise raises the temperature of the oil and breaks down the film of lubrication between worm and gear.

Forced air-cooling, as employed in the new De Laval fan-cooled unit, removes the heat so effectively that the capacity of the gear is doubled for practically all ratios and sizes at 1750 rpm. This permits the use of smaller, lighter and less expensive speed reducers, without sacrifice of efficiency or durability.

As can be seen from the illustration, a fan mounted on the worm shaft draws air at high velocity over and around heat dissipating ribs upon the air side of the oil reservoir housing the gearing. The use of a double wall greatly increases the effectiveness of the cooling by confining the cooling air to the housing and thus securing the close air-to-metal contact necessary for maximum heat transfer.

A complete line of De Laval fan-cooled worm gear speed reducers will soon be available from the De Laval Steam Turbine Company, Trenton 2, New Jersey.



Effective heat removal by air drawn around heat dissipating ribs by a fan increases capacity of this reduction gear.

NEW MOTION PICTURE EXPLAINS GAS TURBINE IN SIMPLE TERMS

▲ The gas turbine, newest source of prime power, makes its motion picture debut in a film released by Allis-Chalmers Manufacturing Company entitled "Tornado in a Box." Explained in motion pictures for the first time are the development and operation of this unit which has been hailed as "the power plant of the future."

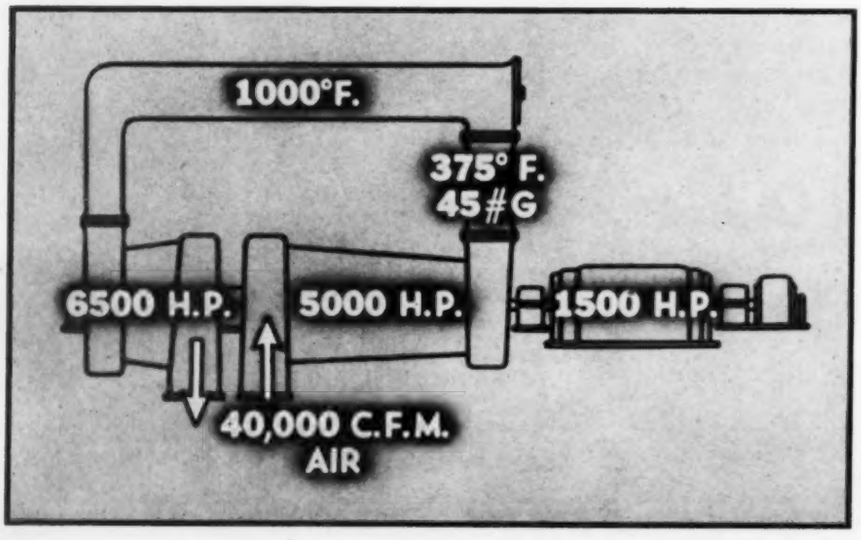
The movie unfolds the story of the gas turbine in a manner which will make its principle readily understandable to the largest possible audience which could be interested in the potentialities of a new prime mover. At the same time, the film frankly indicates that a great deal more of the tremendous engineering effort already applied must still be put into gas turbine development before such potential success can be achieved.

The film, which contains no advertising, will be loaned free to any industrial or engineering group interested in showing it, and permanent prints may be purchased. It is a 16 mm film, for use on sound projectors only.

"Tornado in a Box" is the third of a series of educational films released by Allis-Chalmers, the first being "The Magic of Steam," a story about the steam turbine, the second, "The Surface Condenser."

To borrow or purchase "Tornado in a Box" or the other films, write the Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin.

This diagram from a movie on the gas turbine, illustrates the turbine cycle. The starting motor draws in air, which traverses the axial flow blading where it is compressed. Leaving the compressor, the air flows into the combustion chamber where part of it is mixed with fuel and burned. The compressed and heated gases, trying to expand, flow through the turbine blades, causing the spindle to rotate at high speed, and, after furnishing energy to the spindle, the hot and compressed gases are exhausted back into the atmosphere.



INLAND DEVELOPS NEW ENAMELING STOCK

▲ The problem of successfully applying white or light pastel cover coat vitreous enamels directly to steel surfaces, to which an answer has been sought for years, has at last been solved through development of a new vitreous enameling alloy steel, the latest creation of the research laboratories of the Inland Steel Company, Chicago.

Inland explains that white and other colors of vitreous enamel can be applied directly to the new steel — known as Inland Ti-Namel steel — without the prior application of a base or ground coat enamel.

The remarkable achievement, it is explained, lies in the fact that a thinner covering of enamel produces a better surface, less liable to chip

and with longer service life than the old, more costly multi-coat job.

The new alloy steel reduces enamel shop reoperation, edging and scrap. It permits a lower temperature and shorter time for firing. It increases shop output, and lowers overall enameling cost.

The problem has been that when enamels were applied without a ground coat directly to standard enameling stocks of former days, and fired, the resulting finishes were found to be full of black specks, enamel pits and enamel blisters. This condition was caused by gases, resulting from the reaction of carbon in the base metal with certain constituents in the enamel, when at firing temperature.

Inland, with the cooperation of the Titanium Alloy Manufacturing Company, conducted an extensive research program with the object in view of preventing the formation of such gases and thus eliminating the black specks, enamel pits and blisters.

It was found that titanium when added in a quantity dependent upon the amount of carbon in the base of the metal, would eliminate the cause for pitting, black specking and blistering. The titanium combines with the carbon in the steel to provide titanium carbide which is stable, and the titanium may also combine with the hydrogen entering the steel to form titanium hydride, which is also stable.

Pending patent applications on the new enameling process and product made thereby are owned jointly by Inland Steel Company and the Titanium Alloy Manufacturing Company under trust agreement.

RATIO REGULATOR FOR OIL - STEAM PRESSURE

▲ The Bloom steam-oil pressure ratio regulator provides an automatic means for correctly proportioning the steam pressure to a group of steam atomizing oil burners in proportion to oil pressure.

According to Bloom Engineering Company, the manufacturers, this new regulator eliminates dirty oil burners, improves oil atomization, provides proper flame condition and eliminates the many variables of manual adjustment.

The Bloom steam-oil pessure ratio regulator takes the oilflowring to a set

Gets rid of "Production Gremlins"

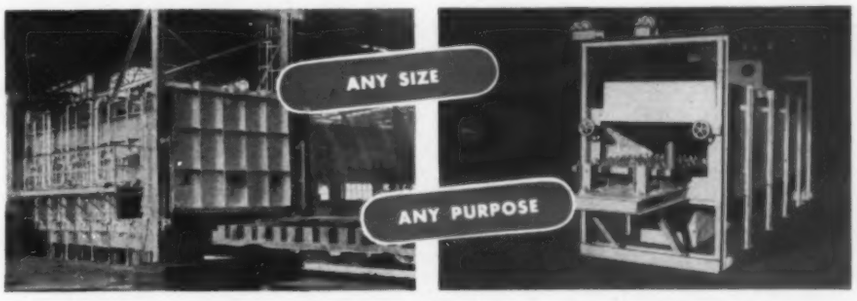
DO warpage, quench cracks, hard or soft spots, low physicals and non-uniform structure and hardness, increase your costs and interfere with your production? Then put your heat-treating problems up to Tate-Jones.

Here at Tate-Jones we have specialized in the fine art of *precision* heat-treating. By scientifically combining the proper heat-treating practice with the correct equipment we make it possible to get out of the steel *all* the desirable properties put into it by the steel maker.

Precision heat-treating is designed primarily to minimize or entirely eliminate re-treating. To give you improved and uniform physicals—uniform hardness and uniform structure. To materially increase machinability, sometimes as much as 100%.

Tate-Jones metallurgists are thoroughly familiar with Austempering, Martempering and Purnellizing. From their long, practical experience with these advanced heat-treating techniques they know how to select and apply whichever method will give *you* optimum results with best economy.

Our combustion engineers and furnace designers are experts in providing equipment, either standard or custom-built, to exactly fit your needs:—Oil and gas-fired furnaces of all types. Salt and lead pots. Oil tempering tanks of the latest types. All engineered to operate at maximum efficiency. Your inquiries will receive prompt attention.



For better results FURNACE ENGINEERS *in heat-treating*

TATE-JONES

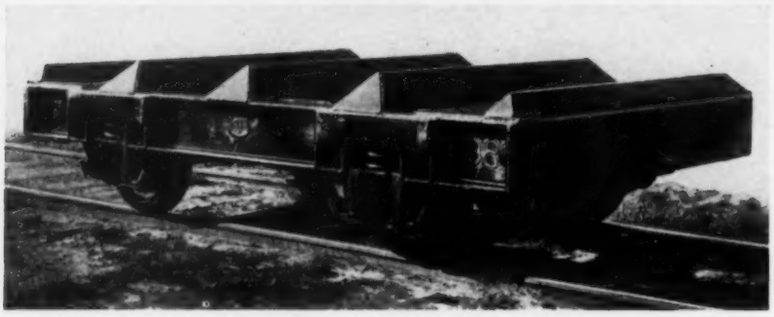
and COMPANY, INC., PITTSBURGH (30) BOX 1014 PA.

Gas and Oil Fired • Pusher • Variable Speed Conveyor • Rotating Hearth • Car Bottom • Roll Down • Horizontal and Vertical Pit • Circular and Rectangular Pot Furnaces • Oil, Gas and Combination Burners

STEEL FABRICATORS

Equipment for Cycle Annealing · Austempering · Martempering · Purnelliging

ROLLER BEARINGS ON SCRAP BUGGIES GIVE EFFICIENT OPERATION



Keeping the steel furnaces filled at the Kaiser plant on the West coast is the job of buggies like this, each with a 25-ton capacity. Constructed by the American Car and Foundry Company, these cars employ Torrington NCS bearings on the axles where they contribute to efficient service because of their low friction coefficient, high load capacity and effective method of lubrication. This application is typical of the many ways in which the unique properties of these bearings aid industry.

of burners through the top chamber of the regulator in order to receive an accurate pressure measurement of the oil pressures going to the burners. The steam pressure chamber is on the opposite side of the diaphragm, and the regulator functions to maintain steam pressure equal to, or greater than the oil pressure, depending upon the minimum setting of the regulator spring.

Three types of adjustment for proper operation are provided — for burners that require steam pressure to be higher than burner oil pressure; for steam atomizing oil burners requiring a definite minimum steam pressure, below which good oil atomization cannot be expected; and for burner conditions where the steam pressure should be lower than the oil pressure.

Bulletin No. 2060 gives a complete description of the Bloom Steam-Oil Pressure Ratio Regulator, as well as specifications and operating diagrams. Copies may be secured through this publication, or by writing Bloom Engineering Company, 857 West North Avenue, Pittsburgh 12, Pa.

ELECTRONICS AID IN STEEL IDENTIFICATION

▲ Electronic timing control on the new Identometer eliminates the human factor in timing tests for positive identification of rolled or forged ferrous alloys, and speeds up the work to a point where it is possible to keep pace with assembly line speeds.

The function of Identometer is to identify rolled or ferrous alloy for stocking or processing. This is accomplished by providing a known sample against which the unknown pieces are checked quickly by the instrument.

The Identometer utilizes the principle of thermoelectricity. All metals and alloys, with the exception of pure lead, exhibit thermoelectric effects to varying degrees. When two metals or alloys are brought in contact with each other and the point of contact is heated, there will be a small current generated, the magnitude of which will depend upon the difference in the materials and the temperature to which the contact is heated. If the two materials are identical, there will be no current generated.

By placing two samples in contact and heating the contact by passing a current through the pieces, the thermoelectric current generated can be measured. This is the principle of operation of the Identometer.

When the new model is properly set up, the power control, the zero adjustment, and the proper test are determined by a pilot test before the instrument and the stock to be tested are turned over to the less experienced operator.

To accomplish a series of tests on similar units, this procedure is followed: The Identometer power dial is set at the proper volume, the zero adjustment receives its proper setting, and the time interval knob is placed on the interval that has been determined by the pilot test for this particular operation. From that point on, all the operator has to do is snap the impulse switch and the test is not only set in motion but maintained there for the correct test interval.

So that the operator may know the progress and completion of each test, the entire reading scale illuminates as soon as the impulse switch is moved and remains fully illuminated until the prescribed test is completed. At that time the full illumination vanishes and a small disc of light appears just behind the test reading, a signal to the operator that this one test has been completed and it is now time to take the reading and attach material for the next test.

The Identometer is manufactured by the Instrument Division of the American Tubular Elevator Company, and is distributed by Dravo Corporation, Pittsburgh, Pennsylvania.

NEW TYPE HEADGEAR PREVENTS INJURIES

▲ Portable Products Corporation, 420 Boulevard of the Allies, Pittsburgh, Pa., are now manufacturing a new type of head protector for guarding the head against injuries. Known as "Beanie" caps, they are made of molded fibre and employ a soft, flexible band which fits any shaped head comfortably. The cap lining and hammock are arranged so as to cushion the blow.

"Beanies" are extremely lightweight, weighing approximately 6 oz. They are particularly valuable to garage mechanics working under an automobile, or to men who must enter and repair the fire-box of a locomotive. Packing house employees wear them to guard the head against moving meat hooks. In general, Beanies may be worn industrially where protection of the skull and scalp is paramount.

STEEL IDENTIFIED BY ELECTRICAL DEVICE

▲ Simple comparisons of ferrous materials as to analysis and heat-treatment are provided by the Ferrograph, a new metal-testing instrument just announced by Allen B. Du Mont Laboratories, Inc., Passaic, New Jersey. This instrument, available on outright sale, can be used to obtain highly useful information about iron and steel very rapidly, just as its larger and more elaborate counterpart, the Cyclograph, is licensed for a far wider range of tests on non-ferrous as well as ferrous materials.

The Ferrograph utilizes the transformer principle of operation. A 23-cycle exciting current is fed into the primary coil while the output of the secondary is controlled by the magnetic characteristics of a metal sample introduced into the coil. The voltage from the secondary is filtered and the fundamental 23-cycle wave is impressed on the horizontal axis of the cathode-ray tube. The third harmonic is viewed on the vertical axis of the instrument.

The first and third harmonics will vary in phase and amplitude with variations in the analysis and heat-treatment of steel or iron. Sorting of commonly used S. A. E. steels is quite practical although in some cases the difference obtained is very small and may not be sufficient for sorting production lots of parts. About 80 per cent of the mixtures of two types of iron or steel that can occur, can successfully be sorted by the Ferrograph.

UNIT SUPPLIES HIGH VOLTAGE D-C POWER

▲ A new line of metal-enclosed, high-voltage d-c power supply units, available in ratings up to 50,000 volts d-c, has recently been announced by the General Electric Company. These units provide a convenient and reliable source of d-c power for applications such as testing of electric equipment; precipitation; induction heating; radio; and miscellensous industrial and electronic applications requiring a high-voltage d-c supply.

Each unit consists of a full-wave kenotron rectifier, a filter to limit voltage ripple to one per cent or less, and complete control equipment — all compactly mounted in an attractively styled steel cabinet. The four kenotron tubes are mounted in sockets integral with the double-conductor, high-voltage terminals on the cover of the single oil-filled tank which contains the combined main and filament transformers. The d-c output voltage can be controlled, from zero to maximum, by means of a motor-operated, dry-type, variable autotransformer. All of the meters, indicating lights, and manual controls for the entire equipment are located on a recessed panel in the upper section of the cabinet.

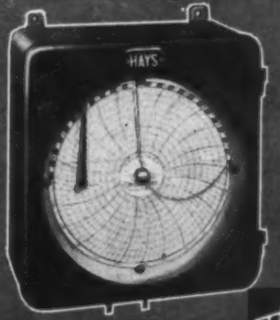
The crackel-black enameled steel cabinet is provided with dust filters to prevent the accumulation of dust and dirt, and the interior is ventilated by an air-circulating fan. If a portable unit is desired, the cabinet can be furnished on a four-wheel dolly truck, or it may be ordered without the truck for built-in applications.

Among the several safety features

A Real Aid to PRODUCTION

TYPE CDE-X FURNACE PRESSURE CONTROLLER

SERIES FOT PRESSURE INDICATOR



SERIES OT PRESSURE RECORDER

HAYS
OPEN HEARTH
PRESSURE CONTROL

TONNAGE can be increased through more even operation and even operation also means fuel saving. Automatic control of furnace pressure, rates of fuel and air flow, ratio of fuel to air, constant volume or pressure of oil or gas relieves the operators of many time-consuming details, allowing them to pay more attention to the steel making process.

When desired, the control of these various functions can be handled manually from a centralized panel through remote operation. Hays control is all-electric, simple to install, simple to operate, simple to understand.

The following Hays instruments may be used effectively in combination or separately for the functions indicated.

Type CDE-X Furnace Pressure Controller with external manual adjustment for automatically operating stack damper to hold pressure constant.

Series FOT Pressure Indicator provides an easily read measurement of furnace pressure. Usually connected at furnace roof.

Series OT Pressure Recorder provides daily record (24 hr. chart) of furnace pressure. Shows timing of reversals and each change of pressure made by operator during the heat.

Hays partial or complete instrumentation is a REAL AID TO PRODUCTION. Hays representatives located in the principal cities of the U.S.A. and Canada will gladly supply complete information.

THE HAYS CORPORATION
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY INDIANA U.S.A.

SWINDELL

ELECTRIC ARC

MELTING FURNACES

Equipped with
G-E AMPLIDYNE
CONTROL

provides MORE TONNAGE WITH LESS POWER—
MORE CONSTANT, UNIFORM CONTROL—
LOW MAINTENANCE-CONTINUOUS OPERATION

Swindell-Dressler and General Electric now combine to provide makers of steel with complete *ACCURACY* and *PRECISION CONTROL* for Swindell Electric Arc Melting Furnaces.

Swindell engineers welcome the opportunity to discuss this development . . . the many ways in which it will provide greater tonnage . . . lower maintenance costs . . . and dependable accuracy of control.

SWINDELL-DRESSLER *Corporation*

DESIGNERS AND BUILDERS OF MODERN INDUSTRIAL FURNACES

PITTSBURGH, PA.

Continue to buy War Bonds

incorporated in the unit is an automatic solenoid-operated discharge switch. This switch is interlocked with the main supply in such a manner that it automatically short-circuits the rectifier and discharges the filter capacitor through a resistor when power is removed. Safety interlocks automatically de-energize the equipment when the cabinet doors are opened.

Complete information is contained in Publication GEA-4317, available upon request from the General Electric Company, Schenectady 5, New York.

NEUTRALIZING AGENT IN COMPOSITION BEARINGS STOPS CORROSIVE ACTION OF ACIDIC WATER

▲ A recent outstanding development in the field of laminated plastics is a new type of Ryertex bearing containing an acid neutralizing agent in its composition. This innovation is the result of many experiments conducted in an effort to overcome the increased rate of wear on bearings that operate with contaminated (slightly acid) water as the lubricant. The action of the neutralizing agent in the bearings counteracts the corrosive attack against the roll necks caused by diluted acid accelerated with excessive heat.

In a bearing assembly composed of a rotating roll neck and a stationary composition material, the principal function of the water lubricant is to provide a separating film between the two surfaces. Thus the roll neck actually rides on an infinitely thin film of water. In operation, this film is never of uniform thickness because even though the surfaces of both roll neck and bearing are highly finished, there are always miscroscopic high and low spots on each. When heavy loads are applied to the roll neck the film is squeezed thinner, causing a breakdown whenever the high points of the bearing and roll neck meet. This film breakdown permits the roll neck and bearing to rub, causing a frictional heat of sufficient intensity to enlarge the film breakdown in localized adjacent areas. In the case of installations using acidulated water for the lubricant, the frictional heat produced at the points of contact where the film is broken releases the corrosive elements in the water and accelerates their attack of the steel roll neck in the local pressure areas. Starting with a microscopic etching of the roll neck, this attack becomes a progressively more vicious cycle as the corroded roughened roll neck surface creates more heat and friction, which accelerates the corrosive action. In time, the roll neck becomes severely pitted and the rate of bearing wear greatly increased.

Until recently, the rapid rate of wear for bearings lubricated with impure water was attributed to direct chemical action on the bearing material itself. Later, tests have proved conclusively that Ryertex is inert to any chemical action in ordinary contaminated waters. Therefore, the impure lubricating water creates a vicious cycle of frictional heat, lubricating film breakdown, corrosive action against the roll necks, pitted roll necks and increased wear.

In water-lubricated bearings there is always a surplus of water used, which serves as both lubricant and coolant. The neutralizing action of the new Ryertex bearing affects only an infinitely small portion of the water used to cool and lubricate the roll necks because the neutralizing takes place only in the localized heavily loaded areas where the roll operates at sufficient pressure to break down the thin lubrication film. In these areas they soon build up temperatures that are sufficiently high to accelerate any chemical action. Thus the neutralizing agent works quickly to counteract the acid and at the same time restore the natural lubricating properties of pure water at that point . . . thereby maintaining the lubricating film, which helps the bearing to run cooler and eliminate corrosive action on the roll necks.

A long period of careful experimenting and testing in the field with many types of impure water has shown a distinct improvement in the condition of the roll necks and increases in tonnages rolled per bearing for over 90 per cent of the Ryertex with the neutralizing agent as compared with any other type of composition bearing. Tests so far have only included the light and medium loaded mills, but other tests are under way using the heaviest type of mill installations.

OXYGEN INDICATOR GIVES RAPID DETERMINATIONS

▲ Bacharach Industrial Instrument Company has just introduced its Fyrite oxygen indicator, a portable gas analyzer that enables rapid determination of 0_2 with an accuracy of ½ of 1 per cent 0_2 at any point of the scale. The instrument employs the fundamental Fyrite principle of chemical absorption. Its accuracy is not altered by vibrations or shock.

A sample of the gas or atmosphere to be tested is pumped into the Fyrite with the aspirator bulb, as illustrated. Release of the finger pressure on the connector at the end of the rubber tubing automatically locks the sample in the calibrated measuring chamber of the instrument. The Fyrite is then turned bottom-side up, and back again, which causes the absorbing fluid to mix with the sample.

This gas analyzer makes oxygen determinations to within ½ per cent of oxygen.

Absorption of the oxygen creates a suction which draws the absorbing fluid up into the graduated tube in an amount equal to the 0_2 absorbed. Thus, the level of the fluid column shows 0_2 percentage, which is read directly on the graduated scale. The standard range is 0 to 20 per cent.

The entire Fyrite 0_2 test, including pumping of the sample, takes about 40 seconds. The process is entirely automatic, and does not require any previous instruction, skill, or training. There are no valves, clamps, or leveling bottle to manipulate.

Additional information on the Fyrite Oxygen Indicator can be obtained by writing for leaflet 700 to Bacharach Industrial Instrument Company, 7000 Bennett Street, Pittsburgh 8, Pennsylvania.

LARGE DOUBLE HYDRAULIC PRESS WILL BEND STEEL PLATE 6 IN. THICK

▲ A little while ago a huge 6000-ton press, biggest up to that time, designed for bending boiler plate up to 6 inches or more in thickness, was delivered by The Baldwin Locomotive Works Southwark Division to Combustion Engineering Corporation's Chattanooga plant, which turns out unusual boilers for industry.

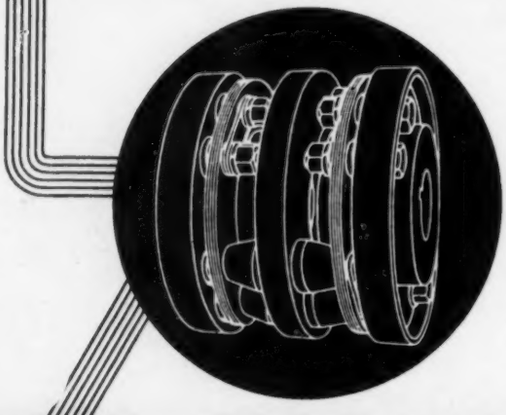
Already that record is being broken at Southwark, for a new press to form heavy plate has just been built — capable of exerting a total pressure of 8800 tons.

In the old days it required 30 days to cold roll and form a boiler shell for riveted construction. The 6000-ton press in use in Chattanooga cut that time to four days by hot forming. And the proposed 8800-ton press will probably reduce the fabrication time still further, besides boosting vessel sizes and steam pressures.

This big press will be capable of bending boiler plate up to six inches or more in thickness and in lengths up to 42 feet. Its overall dimensions are 60 feet wide, 60 feet high (26 feet of the latter below ground). In other words, it is wider by five feet than the press of 6000-ton pressure, 11 feet higher, and extends below ground four more feet.

The press consists of two 4400-ton, four-post hydraulic presses connected by two built-up beams. The two presses operate on a 2000-pound line pressure. One significant feature is its controls. A single operator standing at a conveniently located battery of valves in full view of the work controls the action of the press and plate manipulators. In spite of its tremendous size, it operates simply and fast. Industry regards the big press as a triumph in plate bending and forming. Its engineers say it produces the highest grade of workmanship so far originated and with substantial reduction in time. The method of hot forming, using the normalizing heat, has in itself reduced the time factor over cold forming better than 34 percent. Thicknesses in construction and consequent pressures have been increased beyond limits previously possible.

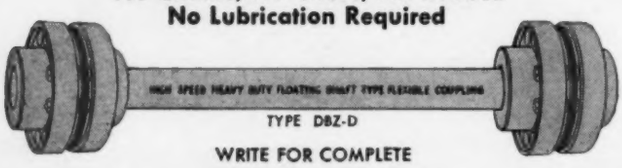
THOMAS
Flexible COUPLINGS



TYPE DBZ
TYPE DSM
TYPE CM
TYPE AM
TYPE-MT
TYPE SS

Eliminate BACKLASH, FRICTION, WEAR AND CROSS-PULL
the four destructive evils of other types and makes of couplings that prevent a permanent care-free installation.

The Thomas All-Metal Coupling has:
No Chains, No Gears, No Rubber.
No Lubrication Required



TYPE DBZ-D

WRITE FOR COMPLETE ENGINEERING CATALOG

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA

ALUMINUM CONNECTORS FOR SUBSTATION BUSES

▲ Anticipating the increased use of aluminum for substation buses, Burndy Engineering Company, New York, has designed a complete line of aluminum connectors for all power needs. The line features a full range of types and sizes for all aluminum-to-aluminum connections as well as for aluminum to copper.

Produced from a heat-treated aluminum alloy high in strength, conductivity and elongation, the Burndy aluminum connectors differ in design from conventional copper connectors. The new design compensates for the differences in the electrical and physical properties of the two metals, and the high elongation of the aluminum alloy permits the connector to conform tightly to the conductor under

pressure without danger of cracking. Thus properly designed, with adequate proportioning and contact surfaces, and utilizing the most efficient alloys, these aluminum connectors provide excellent electrical and physical efficiencies.

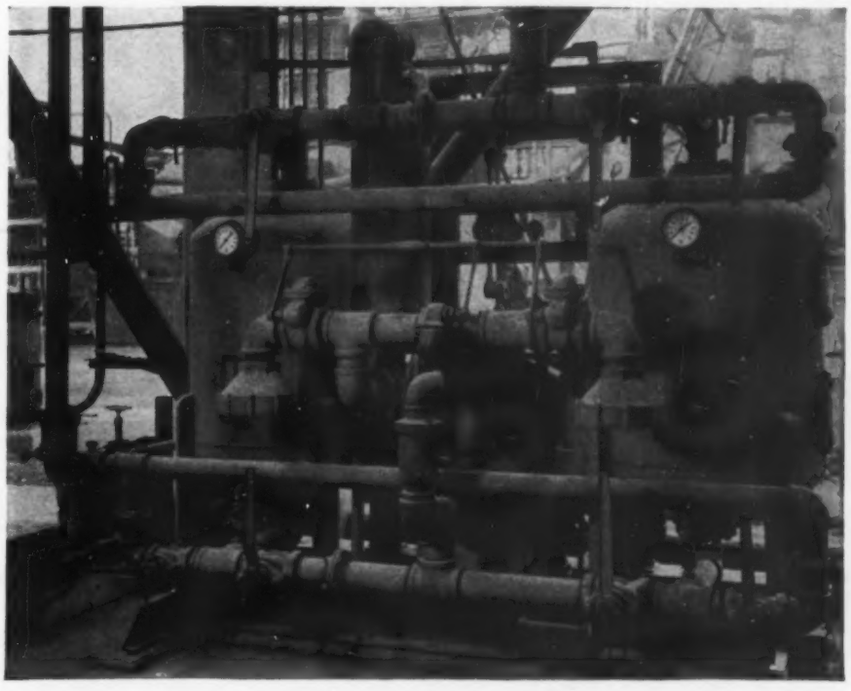
In design, the wall thicknesses of the aluminum connectors are greater, the bosses thicker, and radii larger, and the contact surfaces somewhat larger — features essential to provide the required conductivity and the strength necessary to assure enduring contact pressures in service.

SILICONE INSULATIONS SAVE SPACE AND WEIGHT

▲ "Silicones," a new class of organo-silicon insulating materials are now in commercial production by Dow Corning Corporation of Midland, Michigan it was announced recently. These new products have exceptional heat stability, resistance to moisture and freedom from carbonization at high operating temperatures. They are, therefore, natural complements to inorganic spacing insulation such as Fiberglas, asbestos and mica.

Several types of Dow Corning insulating resins have been under development, each designed for a specific use requirement. One of these new silicone resins, represented by Dow Corning 993 is employed as an impregnant and coating for Fiberglas served magnet wire and for woven Fiberglas electrical tapes, cloth and sleeving. It requires high temperatures to cure to a tack-free state; 1 to 3 hours at 250 C or shorter times at 350-400 C. This combination of Dow Corning 993 with Fiberglas electrical textiles provides flexible continuous insulating constructions which withstand long operating temperatures of 150-200 F in electrical equipment. A third type, represented by Dow Corning 2052, is intended as an impregnant and thermosetting dielectric for rotating parts of electrical equipment. On baking at 200 C, it sets throughout its cross section to a relatively hard resin which does not flow. It was designed primarily to be resistant to centrifugal displacement in parts of electrical equipment rotating at high speeds and at elevated temperatures.

Dow Corning resins are designed primarily for use with inorganic materials such as Fiberglas, asbestos and mica. Since these new organo-silicon resins permit operating temperatures at which paper, cotton and other organic insulations carbonize, they are not recommended for use with such materials. Because Dow Corning insulating resins make possible higher safe operating temperatures, they permit the design of electrical equipment of increased power output, decreased size and weight and improved reliability. When electrical equipment of present design is insulated throughout with Dow Corning resins in conjunction with all inorganic spacing materials, a wider margin of safety from overload failures is obtained due to the heat stability and moisture proofness of the silicone resins.



Specify **KEMP ADSORPTIVE DRYERS**

X instruments = 16 men
X instruments + KIA = 2 men

That's what happened at a prominent refinery. When the Kemp Instrument Air Dryer pictured above was installed, maintenance troubles were materially reduced. Two men can now handle the number of instruments that formerly required sixteen because of frequent freeze-ups and clogged orifices. In the face of today's labor shortages that is important news!

Of more importance to refinery officials, however, **is the fact that DRY** instrument air insured functional instrumentation and gave them accurate control of processing.

For accurate, trouble-free instrumentation, specify KIA Dryers. In fact, it would pay you to consider drying all your compressed plant air—our engineers will gladly submit recommendations for your study.

Ask For Bulletin 25-C.

OTHER KEMP PRODUCTS

Nitrogen Generators • Inert Gas Producers
Atmos-Gas Producers • Immersion Heaters
Flame Arrestors for vapor lines, flares, etc.
The Industrial Carburetor for premixing gases
Submerged Combustion Burners
A complete line of Industrial Burners, and Fire Checks.

Address The C. M. Kemp Mfg. Co. 405 E. Oliver St., Baltimore-2, Maryland.

KEMP of BALTIMORE

New Literature

▲ "Metallography and Heat Treatment of Steel," by E. J. Teichert, is the third and last volume in the Ferrous Metallurgy Series, which includes "Introduction to Ferrous Metallurgy" and "The Manufacture and Fabrication of Steel" by the same author, and previously reviewed in these columns.

This third book is complete in itself and contains fundamental metallurgical information on physical testing and heat treating. Included are discussions on X-ray, gamma-ray and magnetic testing, as well as the more usual tests. Special attention is given to the iron-carbon diagram, the heat treatment of carbon and alloy steels and steel castings, the N. E. steels and to the specific effects of alloying elements. 577 pages $5.00. Published by McGraw-Hill Book Company, 330 West 42nd Street, New York 18, New York.

▲ "Machine Designers Guide," a cloth bound book of 280 pages, is primarily a complete, simple and practical reference book intended for constant use by engineers, designers, draftsmen, etc. It is compiled with the idea of also meeting the needs of those with limited technical education. Separate sections of the book are devoted to mechanics, graphics and strength of materials. Another section gives various tables, mensuration formulae and methods of construction of curves. A large portion of the book is devoted to examples illustrating the various types of problems. This third addition also includes a section devoted to elementary principles of aviation engineering. Published by Machine Designers Guide, Lake Orion, Michigan, $2.75.

▲ The 1944 edition of the A. F. A. Cast Metals Handbook represents a most extensive revision from the previous edition (1940). It deals exclusively with the engineering properties of cast metals and has been prepared especially for use by those who design metal parts and who specify or purchase case metals for industrial products.

Separate and extensive sections deal with Steel, Malleable Iron, Cast Iron, and the Non-ferrous Alloys, all technical data included having been brought up to date in the light of cast metals developments made since publication of the previous edition.

Cloth bound, 745 pages, $6.00. Published by American Foundrymen's Association, 222 West Adams Street, Chicago (6), Illinois.

▲ A booklet entitled "The Cross-Fired Open-Hearth Furnace" by Dr. Gilbert E. Seil, of Day and Zimmermann, Inc., 231 S. LaSalle Street, Chicago, Illinois, describes a new development in furnace design.

This furnace uses nine small burners in staggered positions in the front and back walls rather than one large burner in the ends. Each burner gives a short, sharp, directed flame close to the bath, so that the whole area is covered. The front burners are between and flush with the front buck stays.

This arrangement gives high heat exchange to the bath and reduces the melt down period from 15 to 20 per cent less than normal, as well as giving protection and longer life to the brick work. The scrap is melted from the bottom rather than the top with torch-like flames. This furnace is adapted to the use of any kind of fuel.

No reversals are required on this furnace, so that this time is saved and combustion conditions in the furnace are not changed by the alternating operation of the burners.

▲ Any industrial man who has a problem which must be solved through the use of measuring instruments and controls should be interested in Leeds and Northrup Company's recent publication, which briefly describes all L&N products for regulating plant processes.

Because so many of these processes depend on close temperature regulation, one section of this 28-page "general catalog" issue of "Modern Precision" describes the instruments for measuring by each of L&N's four pyrometric methods: Thermocouple, Rayotube, Thermohm and Optical. For other plant processes, equipments which measure such quantities as pH, speed, gas analysis, etc., are described. A large chart shows the particular instrument model which is available in each case . . . installation photographs show the equipments in service.

Another section is devoted exclusively to a discussion of L&N heat-treating furnaces, with a page describing and illustrating each method: Vapocarb-Hump Hardening, Homocarb Carburizing, Homo Nitriding and Homo Tempering. Also described, in still another section, are the L&N laboratory instruments, long used in industry. And there is a description, too, of those equipments widely used for increasing power plant efficiency.

Anyone not already having a copy of this publication may receive one by writing Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pennsylvania. Please be sure to specify folder ENT(7a).

▲ Complete specifications for the entirely new and recently developed line of Thompson 3-way, 4-wire, 4-pole disconnecting lowering hangers are included in the new 20-page supplement No. 44a to their catalog No. 41.

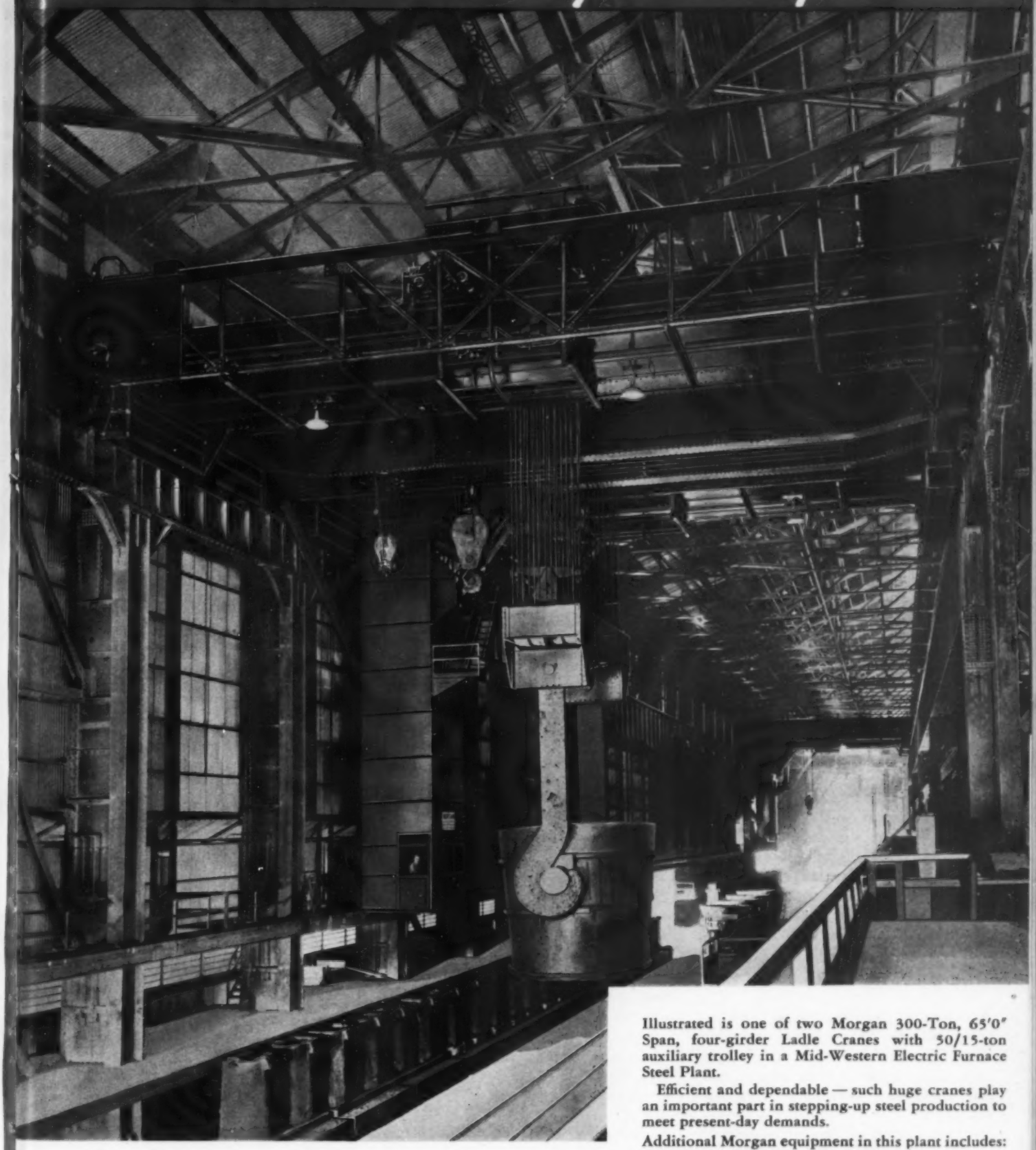
These new hangers are particularly designed for use with high-positioned combination twin or triple unit mercury and incandescent lighting equipment; also where color lighting or various degress of illumination are required. Thompson hangers enable floor or ground level washing, relamping of and repairs to the lighting fixtures at the lowest cost and with perfect safety — no climbing or electrical hazards.

The recently improved and simplified line of the well-known 2-wire, 2-pole single circuit hangers, new parts lists for all hangers, and a number of new accessory items, chain and cable fittings are also fully covered in this supplement, which brings the catalog up-to-date.

It is understood that quite a variety of new and extremely interesting products awaiting post-war release, will be announced later, at which time a complete new catalog will be issued. For copies of the supplement, write The Thompson Electric Company, 1101 Power Avenue, Cleveland (14), Ohio.

▲ Air Reduction, manufacturer of

BUILT BY MORGAN *Engineering*



MORGAN 300-TON, 65′0″ SPAN POURING CRANE

Illustrated is one of two Morgan 300-Ton, 65′0″ Span, four-girder Ladle Cranes with 50/15-ton auxiliary trolley in a Mid-Western Electric Furnace Steel Plant.

Efficient and dependable — such huge cranes play an important part in stepping-up steel production to meet present-day demands.

Additional Morgan equipment in this plant includes:
Three 150-Ton, 65′0″ Span Pouring Cranes.
Two 150-Ton, 80′3″ Span Hot Metal Charging Cranes.
Two 200-Ton, 63′0″ Span Universal Type Ingot Strippers.

THE MORGAN ENGINEERING CO.
ALLIANCE, OHIO. 1420 Oliver Building, Pittsburgh

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES SPECIAL MACHINERY FOR STEEL MILLS

welding equipment and gases, has issued a new bulletin on acetylene generators. It features the new Airco type "P" portable generator, incorporating an "air lift" water circulating system and enlarged radiation space between the carbide hopper and water level which eliminate the "hot belt" and provide cooler, double-scrubbed gas.

The bulletin describes and illustrates the company's complete line of generators, including portable models in 15, 30 and 50 lb sizes with 30, 60 and 100 cubic feet maximum hourly productive capacity. Stationary models are available in 300 and 500 lb sizes which deliver 300, 600 and 1000 cubic feet maximum hourly production.

Copies of the bulletin, which also lists sizes and packaging of National Carbide for use in acetylene gas production, may be obtained from any Air Reduction office or by writing the company's general offices at 60 E. 42nd Street, New York 17, New York.

▲ A new colorful 4-page bulletin completely describes the line of safety marking tools made by M. E. Cunningham Company. Included in the bulletin are details on Cunningham letters, figures and symbols, as well as Cunningham holders for the above.

Cunningham safety marking tools set the standard for safety, dependability and longer service, according to the manufacturer. They will not spall or mushroom, giving deeper impressions and 50 to 100 per cent more service.

Also included in the Cunningham bulletin is a page on the wide variety of safety date and inspection symbols available in Cunningham stamps. Copies of the "Safety Marking Tools" bulletin may be secured by writing this publication, or direct to M. E. Cunningham Company, 105 E. Carson Street, Pittsburgh 19, Pennsylvania.

▲ A new 12-page illustrated booklet, "Oxyacetylene Pipe Line Installations," has been issued by Air Reduction, manufacturers of industrial and rare gases and welding and cutting equipment. The booklet gives a concise description of typical oxyacetylene pipe line plans for various size industrial plants. Written by members of Air Reduction's Engineering Staff, it discusses in detail the advantages of gas piping systems for medium- and large-volume users of oxygen and acetylene in welding, cutting and other flame processes.

Details on pipe sizes, central depot location, station outlets, safety devices, and other pertinent data are included. Schematic diagrams of piping layouts for typical plants ranging from railroad shops to aircraft welding departments are among the many interesting topics discussed. Free copies of the booklet may be secured by writing to Air Reduction, 60 East 42nd Street, New York 17, New York.

▲ Recently issued by Sossner Tap and Tool Corporation, 161 Grand Street, New York, is a new handbook of ground thread taps. In addition to listing the company's standard and special taps, the book gives considerable information on the selection of taps, thread limits, thread design and dimensions, etc. The handbook, which is indexed and well put together in a plastic binding, may be obtained by tap users requesting it upon their company letterhead.

▲ A new bulletin on arc welding electrodes has just been released by Allis-Chalmers Mfg. Company. The bulletin, which gives a complete description of each electrode in the Allis-Chalmers line, also includes separate charts on physical properties of weld metal for each electrode as well as on recommended current values. The electrodes, making up a new Allis-Chalmers line, are both a-c and d-c types and are easily identified by officials AWS classification numbers.

The bulletin L6348 may be obtained by request from Allis-Chalmers Mfg. Company, Milwaukee 1, Wisconsin.

▲ Cochrane tilting U-tube mechanical type meter is illustrated and described in publication 3010-31 which will be sent upon request.

Three fundamental features are incorporated in this high torque mechanical meter.

(1) Flow measurement by response to difference in pressure by a mercury seal in a U-tube.
(2) Weighing mass by means of a beam balance.
(3) The use of torsion tubes as the scientific solution of the stuffing box problem.

The Cochrane mechanical meter has exceptionally high operating torque and therefore high accuracy over long life. For copies of the bulletin, write Cochrane Corporation, 17th and Allegheny Avenue, Philadelphia (32), Pennsylvania.

▲ Cochrane reprint No. 32 is descriptive of some important theoretical considerations demonstrating characteristics of acid regenerated carbonaceous zeolites. The article summarizes extensive research work when using sulphuric acid as the regenerant and shows the characteristics of various salts, singly and in combination. A paper that is of interest to anyone interested in the theoretical considerations of this unique method of water conditioning, or to those interested in the purchase of this type equipment for boiler feed or process requirements.

▲ A six page folder on the Punch-Lok method of banding and splicing electrical applications has just been published, and copies may be obtained from The B. F. Goodrich Company, Akron, Ohio, which distributes the product nationally.

The folder describes the tools used in the Punch-Lok method, lists sizes of preformed and open end clamps available in Everdur, a copper brass alloy for electrical use, and tells in step-by-step detail how to apply the Punch-Lok bands on many electrical jobs such as connecting, splicing, reinforcing, tieing and repairing lines.

▲ A four-page bulletin entitled "Meehanite — the Metal for Heat Resisting Castings" has been prepared by the Meehanite Research Institute of America, Inc., Pershing Square Building, New Rochelle, New York. The leaflet, known as Bulletin No. 21, illustrates typical applications of various special heat resisting Meehanite castings and also tabulates various property data. A copy will be mailed free upon request.

▲ A three color folder giving complete data and prices to industrial plants on steel stamps is now available to all who request it from The Acromark Company, 338 Morrell Street, Elizabeth, New Jersey. The folder covers the steel letter and figure stamps developed for the use of industrial plants producing heavy and light precision machine products. They are recognized as a great advance in this field, with markings for convenient use, strong body, well designed shape and finish that goes only with good tools.

What are you waiting for? The boys that are doing the big job over there, are depending on *you*—over here, to win the peace . . . America's *economic* reconversion is already under way and your business is a vital cog in this national machinery. You *are* America.

Action, gentlemen, is needed now!

HERE'S HOW YOU CAN HELP . . . (1) Make an immediate analysis of your reasonable needs to begin post-war business. (2) Place unrated orders for this material to be delivered as soon as restrictions permit. (3) Advise your customers to do the same. (4) Keep up to date on W. P. B., and O. P. A. rulings.

HERE'S HOW IT WORKS . . . Unrated orders placed *now* permit your suppliers to anticipate your needs and begin actual production on them as soon as the W.P.B. lifts the bars. This will assure you of a quicker return to civilian business. The orders *your* customers place with you will provide a back-log to start you off when Uncle Sam ceases to be the one big buyer.

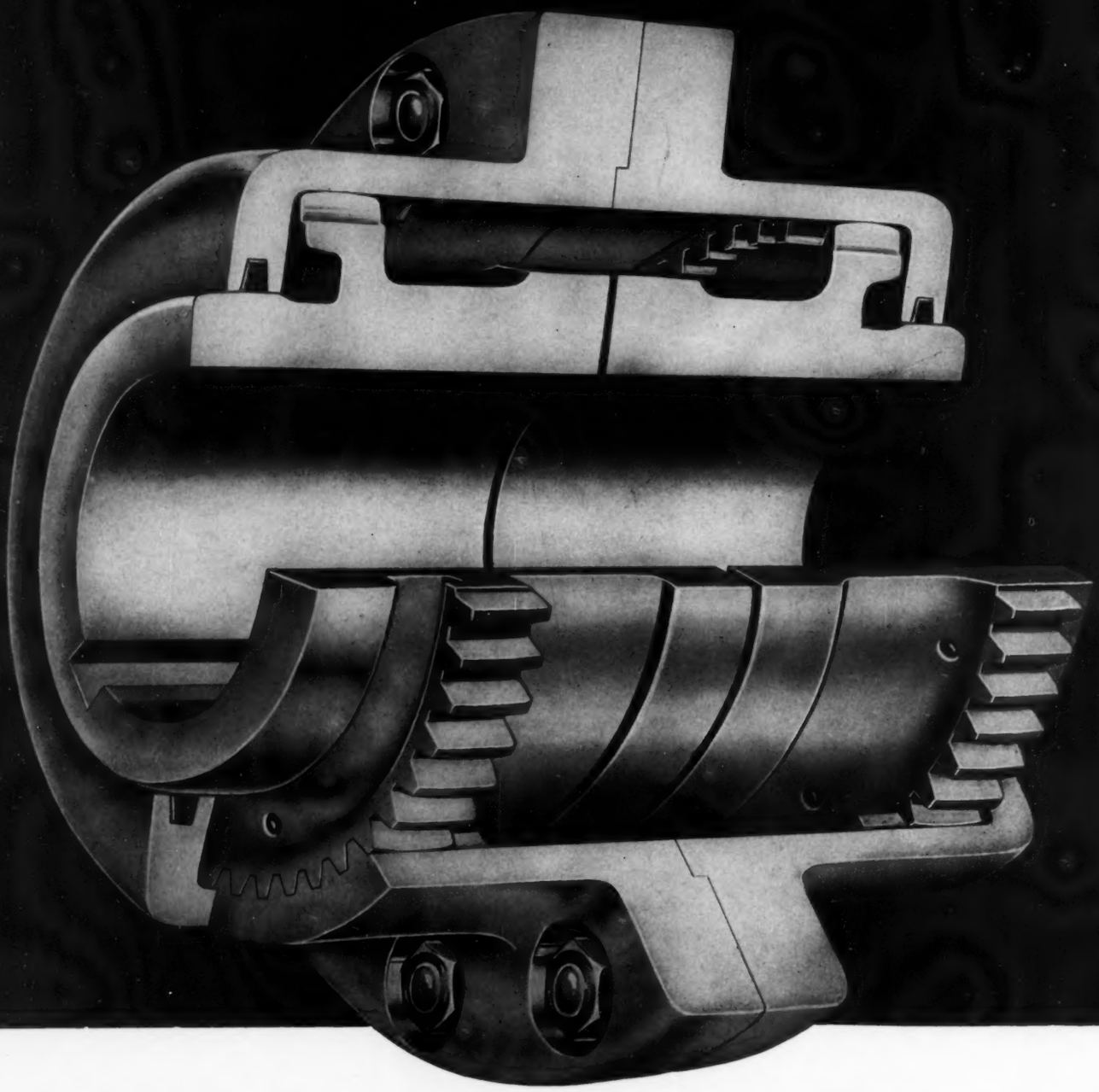
With all business following this plan the gap will be shortened—payrolls will be stabilized—returning veterans will find work—America will continue its job of supplying the markets of the world.

HEPPENSTALL, the most dependable name in forgings

Your personal war effort is important (1) *Push production* (2) *Plan for peace* (3) *Beat 'em with bonds*

HEPPENSTALL CO., PITTSBURGH 1, PA.

POOLE

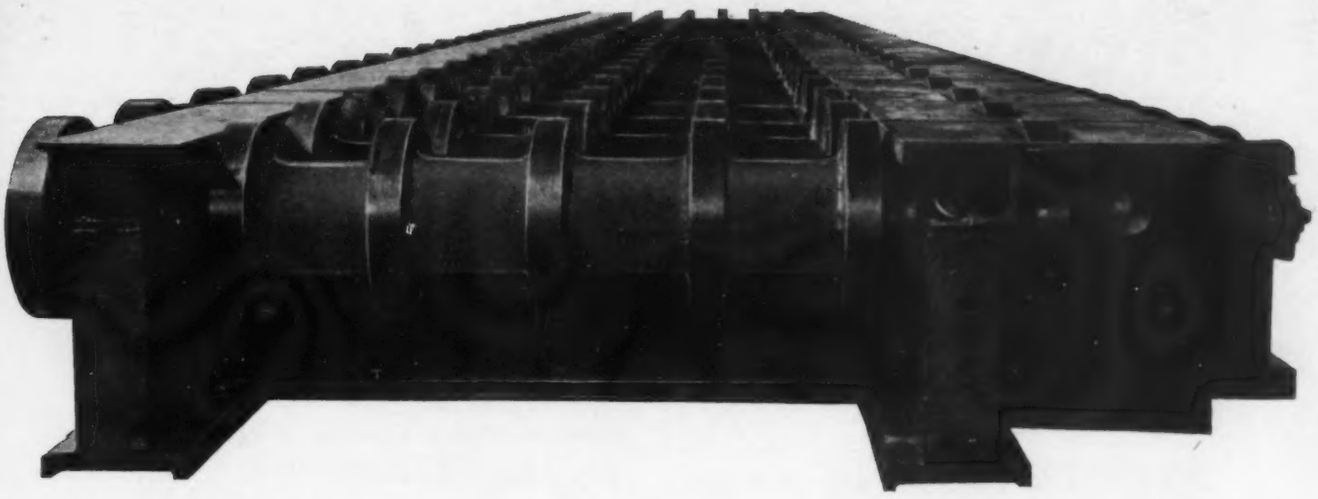


A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.



From This Table...

115,000 lb. Slabs--Served Piping Hot

This Birdsboro heavy-duty runout table serves the world's largest (206") plate mill. It handles slabs for armor plate up to 25" thick and weighing 115,000 lbs., as well as plates up to 17 feet 3 inches wide. The exceptionally rugged construction of this table enables it to withstand the severe impact and terrific heat of the ponderous slabs that travel its course at a temperature of 2000 degrees F.

Once again Birdsboro engineers have combined their skills to produce a piece of heavy-duty mill equipment to meet a specific need. Whatever your steel mill equipment problems may be, bring them to Birdsboro, and we will help you to find the solution quickly and satisfactorily. Write us today.

BUY WAR BONDS

BIRDSBORO STEEL FOUNDRY AND MACHINE COMPANY, BIRDSBORO, PA.

BIRDSBORO

STEEL MILL EQUIPMENT

Stop production losses!

Don't wait until a machine goes down for the lack of lubrication. Install Farval and prevent production losses by keeping your bearings as fit as new, at all times.

A Farval Centralized System of Lubrication will keep unfailing watch over each bearing—will deliver a positive measured charge of oil or grease to every bearing on the machine in less than one minute—and not a bearing will be missed.

One breakdown will pay for many lubricating systems. One lubricating system installation will prevent many breakdowns.

Get ready with lower costs today. You will need them tomorrow. The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing
In Canada: PEACOCK BROTHERS LIMITED

Personnel News

James W. Corey has been elected president of the Reliance Electric and Engineering Company, Cleveland, Ohio, succeeding **Clarence L. Collens** who has been elected to the newly-created post of chairman of the board. Mr. Corey started with Reliance in 1911 in the engineering department. He moved to the sales department in 1916, becoming sales manager in 1932. In 1940 he was named vice-president in charge of sales. He has served as a director of the company for 9 years.

JAMES W. COREY

A. M. MacCutcheon, engineering vice president of Reliance Electric & Engineering Company, has been elected senior vice president succeeding **H. M. Hitchcock,** who resigned.

C. V. Putnam, after 38 years with the Reliance Electric & Engineering Company, has retired to be succeeded in the office of secretary by **Roscoe H. Smith,** who will continue his duties as head of the sales promotion department.

Edward E. Helm, since 1928 district sales manager in Philadelphia for The Reliance Electric & Engineering Company, Cleveland, has been appointed general sales manager of the company. Mr. Helm, who has been with Reliance since his graduation from Pennsylvania State College in 1924, has managed both the Birmingham and Philadelphia territories and has been particularly active in application work in the steel, textile and paper industries in these territories. **Kenneth S. Lord** will succeed Mr. Helm as manager of the Philadelphia district. A graduate of the Massachusetts Institute of Technology, Lord came to Reliance in 1926, and since that time has seen service in the company's Chicago, Pittsburgh, Birmingham and Greenville district sales offices.

Erwin E. Bowen, plant manager of Follansbee Steel Corporation, resigned recently after 25 years' service with the company. Mr. Bowen started as a clerk in the bar mill, worked in various departments of the mill and became superintendent of the sheet finishing departments. He was then promoted to general superintendent and finally was given the post of plant manager.

Edward Hurl succeeds Mr. Bowen as plant manager of Follansbee Steel Corporation. Mr. Hurl has been an employee of the company for the past 20 years.

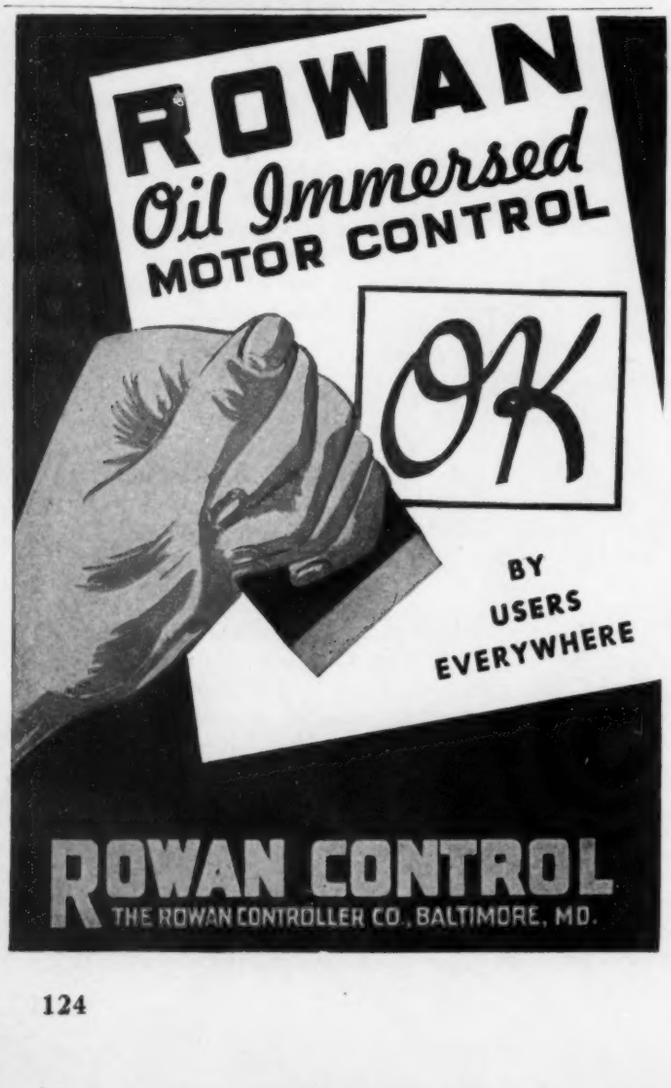
EDWARD E. HELM

Richard S. Johnson has been appointed research engineer on the staff of the chief engineer of the Philadelphia Division of The Yale & Towne Manufacturing Company. The appointment of Mr. Johnson, for ten years chief engineer of the International Chain Company, York, Pennsylvania, is part of Yale's expanding production program of materials handling machinery.

W. R. Duda, former chief engineer, has been made vice president in charge of engineering, for Continental Foundry and Machine Company. The company also announced the appointment of **W. L. Berghoefer** as vice president in charge of casting sales, and **B. P. Hammond,** manager of casting sales in the Pittsburgh district.

R. W. Davis has been appointed general manager of the Allis-Chalmers Manufacturing Company's Norwood, Ohio, works. Previous to this appointment, Mr. Davis was assistant manager of Allis-Chalmers' electrical department at Milwaukee, Wisconsin, but for nearly two years he had been on leave to serve as director of the Electrical Equipment branch in the War Production Board. He entered the Allis-Chalmers electrical department in 1910 after completing the company's graduate engineer training program. Prior to that, he had received a degree in electrical engineering from the Massachusetts Institute of Technology in

IMO Reliability
IN NAVAL
SERVICE
The reliability of IMO "lube" and fuel oil service pumps is typified by their trouble-free performance on a United States Destroyer reported to us by the Navy as having steamed over 84,000 miles on convoy duty during the past year, often cruising as much as 28 days per month without time for normal upkeep and overhaul.
Ask for
Catalog I-115
IMO PUMP DIVISION
of the De Laval Steam Turbine Company
Trenton 2, New Jersey



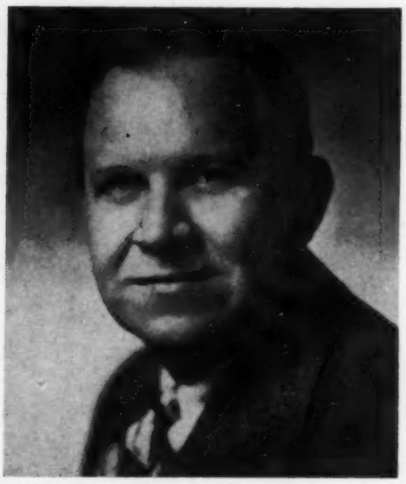
1908, and had been graduated from the University of South Dakota in 1906.

P. C. McKenzie announces opening of offices at 545 William Penn Place, Pittsburgh, Pa. Mr. McKenzie represents The Griscom-Russell Company, The Fluor Corporation, Ltd., and the Scovill Manufacturing Company.

Robert W. Biggs has been appointed manager of the McKeesport Works of Jones and Laughlin Steel Corporation it was announced recently. Mr. Biggs, who has been production manager at the McKeesport works since March 1943, succeeds the late **Walter B. Minch.** Coming to Jones and Laughlin in 1938 as assistant to the superintendent of the Tube Division at Aliquippa, Pennsylvania, Biggs graduated from Ohio Northern University in 1930 as a Mechanical Engineer and worked for the National Tube Company at their plant in Lorain, Ohio, before joining the operating department at Jones and Laughlin.

Ross O. Laub has been promoted to the position of superintendent of cost planning of the Gary sheet and tin mill of Carnegie-Illinois Steel Corporation, U. S. Steel subsidiary. Mr. Laub has been associated with the mill since June 1927. He has served in various engineering capacities and in recent years headed the industrial engineering organization in the plant.

H. C. Andersen who succeeds Mr. Laub as plant industrial engineer at the Gary Sheet and Tin Mill, Carnegie-Illinois Steel Corporation, has been associated with the Gary mill since 1937.



ELMER T. CARLSON

John H. Trumbull, president of The Trumbull Electric Manufacturing Company, has resigned from active service, effective at the end of the year. Stepping out at the same time are **Frank T. Wheeler,** vice president, **Henry Trumbull,** treasurer, and **Stanley S. Gwillim,** secretary and general manager.

Elmer T. Carlson is the newly elected president of The Trumbull Electric Manufacturing Company. A graduate of Northeastern University, Mr. Carlson

entered the electrical contracting business and later was employed by the Hixon Electric Company of Boston, Massachusetts. He joined the Trumbull Company as a sales representative in 1928 and has since progressed through various positions with the company.

Other newly elected officials include **Robert C. Graves,** vice president in charge of sales; **Cecil A. Bedford,** vice president in charge of manufacturing; **Herman A. Papenfoth,** secretary and treasurer, and **Richard L. Goodwill,** assistant secretary and treasurer.

These five newly elected officers represent a total of 119 years of combined service with the company although averaging only 46 years in age.

George L. Stout, who was recently appointed Cleveland district representative for The Trumbull Electric Manufacturing Company of Plainville, Connecticut, has been made manager of that district. **C. F. Latham,** former manager, has been transferred to the New York District office.

Paul M. Mueller has been appointed chief engineer in charge of development for the Blaw-Knox Company. Mr. Mueller was headquarters engineer for the Revere Copper and Brass Company for the past nine years. He received his engineering education at Iowa State College and has had a broad mechanical engineering experience.

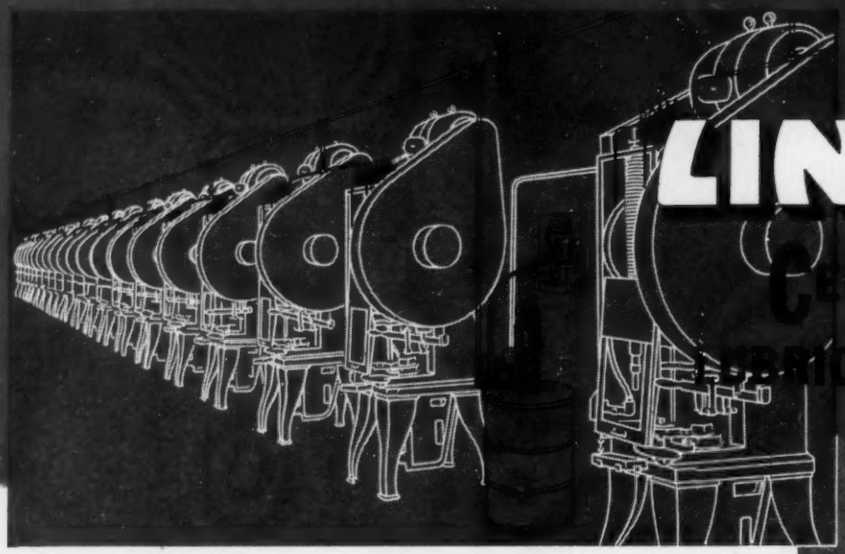
P. S. DICKEY

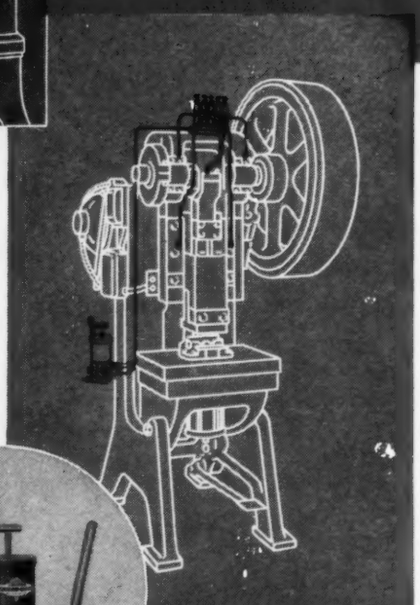
P. S. Dickey has been named chief engineer of the Bailey Meter Company, Cleveland, Ohio. Mr. Dickey will supervise all engineering, research and design activities for the company. He will be assisted by **H. H. Gorrie,** assistant chief engineer, and **R. E. Clark,** manager of contract engineering.

S. M. Rust, retiring president of The Rust Engineering Company, has been elected chairman of the company's board of directors, and **S. M. Rust, Jr.,** who has been serving as executive vice president, has been elected president of the company. Mr. Rust, Sr., founded the company in 1905 with his brothers, **E. M. Rust** and the late **E. J. Lee Rust,** engaging in engi-

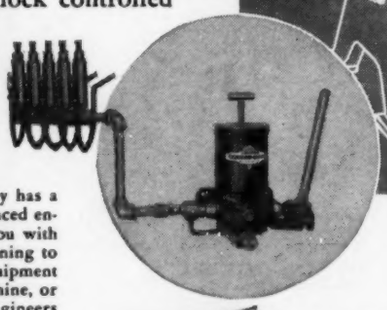
(*Please turn to page 127*)

You can LUBRICATE ONE MACHINE OR A BATTERY OF MACHINES with the LINCOLN CENTRO-MATIC LUBRICATING SYSTEM





The schematic drawings, above and at right, show the flexibility and ease of installing a Lincoln Centro-Matic System on one machine or a number of machines. No alterations are necessary in the orginal machines... Only one lubricant supply line is required... Injectors can be mounted singly or in manifold... Flexible feeder lines can be used on bearings located on moving parts of machine... A single lubricant pump can supply one machine or a battery of machines... Pump can be either hand operated, time-clock controlled or push-button controlled.



Save BEARINGS MACHINE HOURS MAN HOURS POWER and Prevent Accidents

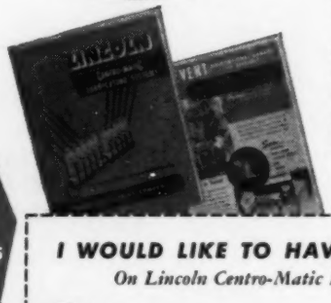
ARMY E NAVY

ENGINEERING SERVICE

The Lincoln Engineering Company has a trained staff of thoroughly experienced engineers who are ready to assist you with any problems you may have pertaining to the lubrication of machines and equipment—Just send us a sketch of the machine, or machines to be lubricated and our engineers will gladly submit a detailed report as to the type of Centro-Matic System required to do the job.

Send for Bulletins Today

Complete, descriptive literature on Centro-Matic Lubricating Systems is available. Mail coupon below and your copies will be mailed immediately.



I WOULD LIKE TO HAVE FREE BULLETINS
On Lincoln Centro-Matic Lubricating Systems

Name _____
Title _____
Company _____
Address _____
City _____ *State* _____

ISE 144-16

LINCOLN ENGINEERING COMPANY
Pioneer Builders of Engineered Lubricating Equipment
5701 NATURAL BRIDGE AVE., ST. LOUIS 20, MO., U. S. A.

neering design and construction of complete industrial plants and facilities. Mr. Rust, Jr., entered the organization after graduation from Lehigh University in mechanical engineering, working in the field and in various other capacities before becoming vice president.

J. E. Reagan has been made director of sales and service of The Elco Lubricant Corporation, Cleveland, Ohio. Mr. Reagan is well known in the automotive and industrial field, having been general service manager of the Timken Roller Bearing Company for many years.

Theodore H. Sanderson has been appointed division superintendent of the armor plate division at Gary Works, Carnegie-Illinois Steel Corporation, succeeding the late **E. N. Yost.** Mr. Sanderson began his service in the corporation in October 1933 as assistant engineer in the metallurgical department in the Chicago office. On February 1, 1939 he became assistant to the superintendent of the rail mill at the company's Gary, Indiana, works and on the opening of the armor plate plant in October 1942 he was transferred there as assistant superintendent of quality control.

Willis T. Cramer has been named assistant director of research of the American Steel & Wire Company, U. S. Steel subsidiary, succeeding **Raleigh H. Barnes,** deceased. Mr. Cramer has been promoted to his new position from the company's Cuyahoga Works where he has been works metallurgist since 1940.

J. H. Callan has been elected president of the Crucible Steel Company. Mr. Callan has been associated with the Crucible Steel Company of America for twenty-four years and has been a member of the Board of Directors and the Executive Committee of the company for the past six years.

Kenneth McCreary was recently elected president of the Goetze Gasket & Packing Company, Inc., New Brunswick, New Jersey. Mr. McCreary, who has been associated with this company since 1932, has served consecutively as assistant to the President, Treasurer and Vice-President and Treasurer. He succeeds **Mr. Frederick Goetze,** who died on January 30, 1944.

O. B. Wilson has been named New York industrial manager for the Brown Instrument Company, precision industrial instrument division, Minneapolis-Honeywell Regulator Company. His appointment becomes effective the first day of the year. Mr Wilson has been with the Brown company for 21 years during which time he has served in several branch offices throughout the country and at the company headquarters at Philadelphia.

J. A. Robinson has been named industrial manager of the Chicago branch of Brown Instrument Company, precision industrial instrument division, Minneapolis-Honeywell Regulator Company, succeeding Mr. Wilson. Mr. Robinson has been with the Brown organization 15 years and has represented the company in several territories. For the past several years he has been connected with the Chicago branch.

DEPRECIATION AND OBSOLESCENCE

IN our domestic markets alone, without considering the demands of vast foreign reconstruction, there is famine in steel for peace uses.

Railroads are wearing out. Present household utilities and motor cars will emerge obsolete with peace. Billions of dollars' worth of deferred demand for miscellaneous items because of restricted materials awaits the readjustment of industry.

Trying as it has been for most of us, the war will have "cleaned house" in America, and after a brief period, industry should enter the greatest era of prosperity it has ever known.

NATIONAL ROLLS, in common with other good rolls that have kept abreast of modern, metallurgical improvements, are ready for what we believe will be a record world demand for steel — possibly even greater in volume than current record production.

The NATIONAL ROLL & FOUNDRY COMPANY
All Grades of Cast Rolls—Iron and Iron Alloy—Steel and Steel Alloy
Heavy Iron Castings and Rolling Mill Equipment
AVONMORE, PA.

OHIO
Extra Strength
MAGNETS

Below a 55" Double strength magnet.

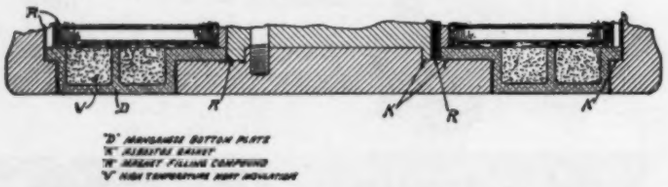
The OHIO 6 pancake coil magnets in the 55" and 65" diameters will average 35% better lifts than the standard magnets.

The OHIO 8 pancake coil magnets will average 75% more than the standard magnets.

Labor cost per ton and time required to handle are both reduced correspondingly.

Numerous repeat orders testify that performance equals or exceeds the statements above.

★When OHIO magnets are required to lift hot materials the heat resisting bottom construction shown below successfully retards the flow of heat from the load to the magnet coil and permits all day use.



Have you a problem requiring fast lifting or lifting of hot steel?

The OHIO Electric Mfg. Co.

5907 Maurice Avenue Cleveland 4, Ohio

L. J. Kramer has been made superintendent of the lapweld tube department of Allegheny Ludlum Steel Corporation, Brackenridge, Pennsylvania. Mr. Kramer, who has worked in the same department for over twenty years, succeeds the late **Charles Rupert.**

Gilbert D. Dill has been appointed a member of the sales engineering staff of American Foundry Equipment Company, Mishawaka, Indiana. He will be engaged in the development and application of Wheelabrator airless abrasive blast cleaning equipment in the rolling mill industry.

Mr. Dill was previously employed as purchasing engineer for Arthur G. McKee and Company, Cleveland, in charge of purchases involved in the construction of two wartime steel plants.

Obituaries

Walter J. Krause, electrical engineer for the Ohio Electric Manufacturing Company, died November 9 at Cleveland, Ohio. Mr. Krause gained his initial experience in the design of electric motors with The Emerson Electric Company of St. Louis and has been with the Ohio company for 25 years.

Alfred Jones, chief electrician at Eliza Furnace Department, Jones and Laughlin Steel Corporation, died recently after an illness of one year. He was 59 years old and had been with Jones and Laughlin for about 30 years.

Dudley H. Miller president of the Speer Carbon Company died recently at St. Mary's, Pennsylvania. Mr. Miller was born in Armstrong County, Pennsylvania, in 1870 and after a varied experience in several industries, came to St. Mary's, in 1921 as vice president of the Stackpole Carbon Company. He retained this position until May 1924, when he became the chief executive officer of the Speer Carbon Company.

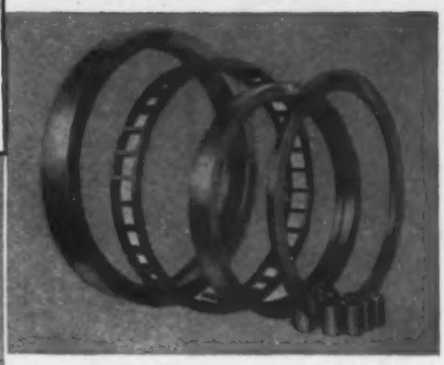
At the time of his death, Mr. Miller was president and director of Speer Carbon Company, president and director of International Graphite & Electrode Corporation, president and director of International Graphite Corporation of Canada, Ltd., president and director of Speer Resistor Corporation, executive vice president and director of the Duriron Company, Inc., and treasurer of the Guerrero Trading Company of Mexico.

Joseph L. Vergilio, founder and owner of J. L. Vergilio Company, Cleveland, Ohio, died of pneumonia after two weeks illness.

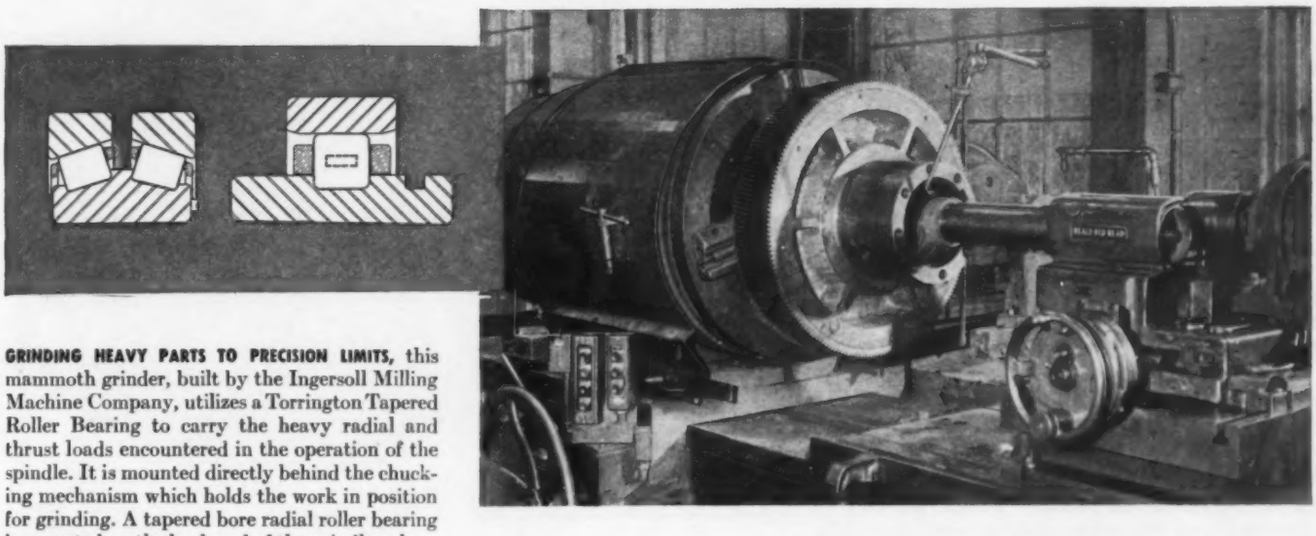
Mr. Vergilio's early life was spent in Erie, Pennsylvania, where he received his education and his early business experience.

On return from overseas service in the first world war, he marketed various types of equipment and about 1924 started his present business in Cleveland, now representing Cochrane Corporation; Associated Research, Inc.; Buffalo Meter Company, Esterline-Angus Company; Hays Corporation; Magnetrol, Inc.; Simpson Electric Company; and Vulcan Soot Blower Corp.

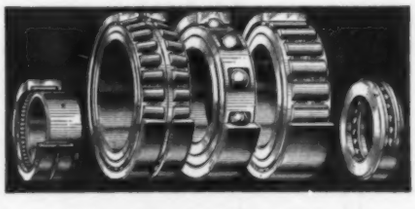
IN THE NEWS
WITH TORRINGTON BEARINGS



MEETING DESIGN REQUIREMENTS of the Emsco Derrick & Equipment Company, the engineers of Torrington's Bantam Bearings Division custom-built the 27½" O.D. Radial Roller Bearings employed in the sheaves of the crown and traveling blocks. The bearings, mounted on a center drum, are located close to the rope grooves to conserve wire line, prevent hazardous tilting, and to minimize wear on the sheaves.

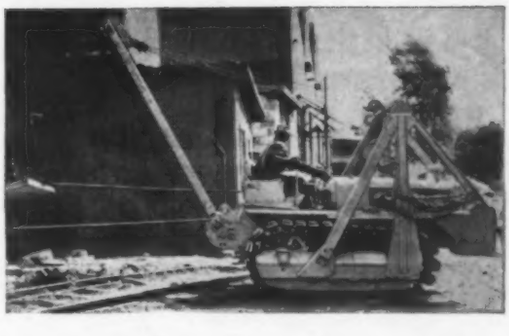


GRINDING HEAVY PARTS TO PRECISION LIMITS, this mammoth grinder, built by the Ingersoll Milling Machine Company, utilizes a Torrington Tapered Roller Bearing to carry the heavy radial and thrust loads encountered in the operation of the spindle. It is mounted directly behind the chucking mechanism which holds the work in position for grinding. A tapered bore radial roller bearing is mounted on the back end of the spindle, where a "V" belt pulley connects direct to the motor drive. After four years in operation the eccentricity and face run-out of these bearings is .00025.



EVERY MAJOR TYPE OF ANTI-FRICTION BEARINGS is included in the Torrington line—straight roller, tapered roller, needle and ball. In addition to supplying every branch of industry with a wide range of standard bearings, the engineering staff of Torrington's Bantam Bearings Division designs bearings in large sizes and of special types for new or unusual applications. For experienced counsel in meeting today's requirements—or assistance in postwar plans TURN TO TORRINGTON.

DESIGNERS of this Williamette Hyster towing winch, installed on a Caterpillar tractor, specified heavy-duty Torrington Needle Bearings for use in the idler and reverse gears. The Williamette Hyster Company says, "Because of the restricted space in the comparatively small gears, needle bearings are the only practical type of anti-friction bearings that can be used."



ARMY ★★ E ★★ NAVY

TORRINGTON BEARINGS

STRAIGHT ROLLER • TAPERED ROLLER • NEEDLE • BALL

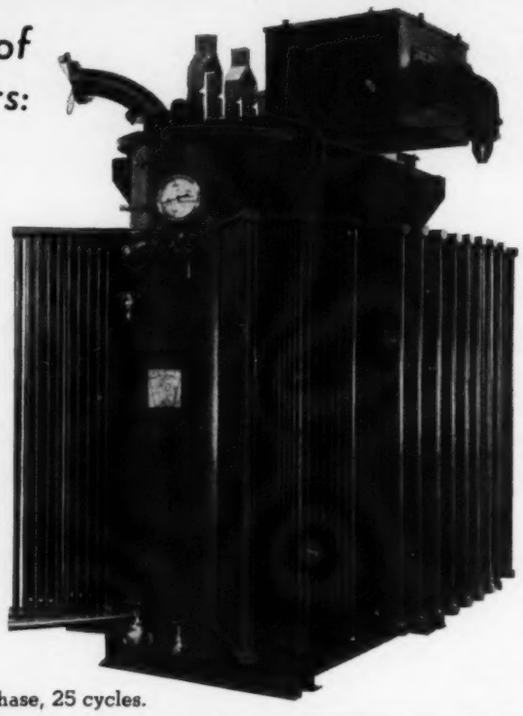
THE TORRINGTON COMPANY • BANTAM BEARINGS DIVISION
SOUTH BEND 21, INDIANA

For convenience and economy of transformer installations indoors near the load centers

Ask for Askarel

Pennsylvania's noninflammable, non-explosive, liquid-filled transformer

Check these outstanding qualities of Pennsylvania Askarel Transformers:



3000 kva, ASKAREL, 3 phase, 25 cycles.

Circular Coils Possess Maximum Inherent Strength

In regular oil-cooled transformers, varnish is used to increase the mechanical and electrical strength of the transformer coils, irrespective of the shape of the coils. This kind of varnish, however, cannot be used to treat coils in a transformer where noninflammable liquids are employed. Therefore, without the aid of this varnish, it is imperative that the coils in a noninflammable transformer have great inherent strength. Pennsylvania circular coils possess the maximum inherent mechanical and electrical strength!

Radiators Built to Withstand High Pressures

Askarel transformers develop high pressures inside the tank because of the sealed, pressure-tight, tank construction necessary to prevent loss of Askarel through evaporation. Sturdy Uni-Row radiators on Pennsylvania Askarel transformers are designed to meet these high pressures. As rugged as the tanks themselves, these radiators are premanently welded in position and tested at 100 lbs. pressure. Radiators are spaced around the tanks so that each tube of each radiator is easily sandblasted, cleaned and painted.

Self-Reclosing Safety Valve Relieves Excessive Pressures.

Safety valves are mounted on the covers of all Askarel transformers above 25 kva, and operate in case abnormal pressures exceeding 12 pounds per square inch develop inside the tanks. These safety valves are self-reclosing to prevent foreign matter from entering the transformers.

333 kva, ASKAREL, 1 phase, 60 cycles.

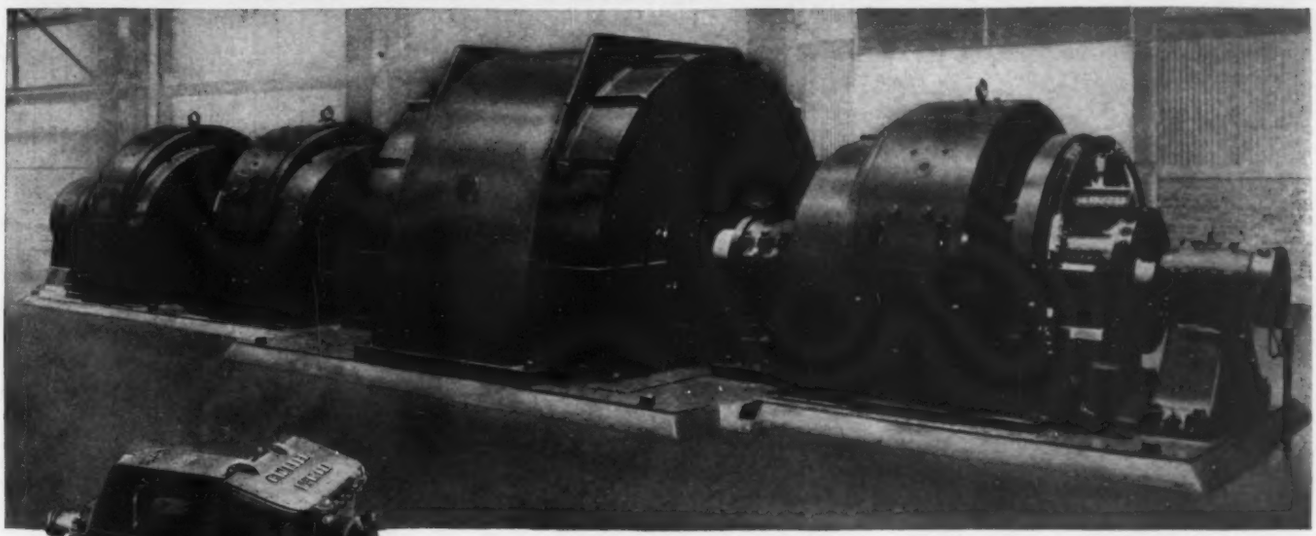
25 kva, ASKAREL, 1 phase, 60 cycles.

Pennsylvania TRANSFORMER COMPANY
PITTSBURGH, PENNSYLVANIA

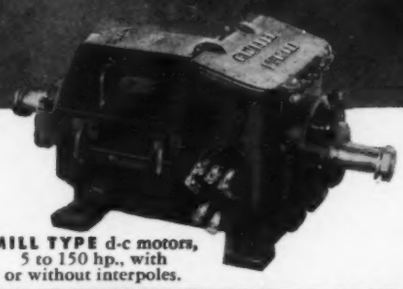
Pennsylvania TRANSFORMERS

- Since Askarel Transformers are noninflammable and nonexplosive, they may be installed indoors at the load centers without a vault or fire door.
- Since Askarel is nonsludging and nonoxidizing, and the transformer tanks are pressure-tight and moisture-proof, Askarel transformers may be installed outdoors as well as indoors.

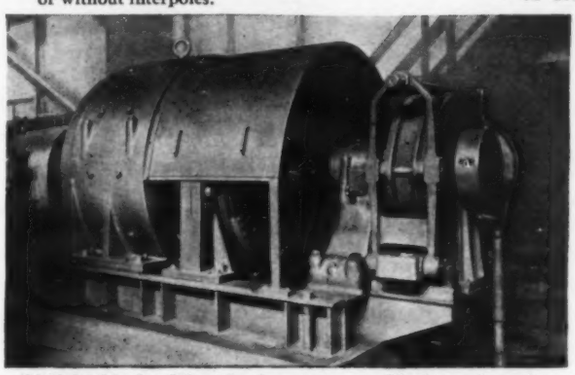
CROCKER-WHEELER POWER for IRON and STEEL INDUSTRY



D-C POWER SUPPLY for a modern mill consisting of two 1250 kilowatt, 600 volt d-c generators and one 1,000 kilowatt, 250 volt d-c generator, all driven by a 4,800 kilovolt-ampere, 6,600 volt, 25 cycle, 3 phase synchronous motor.



MILL TYPE d-c motors, 5 to 150 hp., with or without interpoles.



TAILORED d-c drives for important auxiliaries such as the 700 horsepower, 500 rpm slab squeezer drive motor, above, provide the flexibility of power and speed necessary for maximum all-out production.

CROCKER-WHEELER motors and generators help sustain the all-time high degree of electrification of the steel industry. This "know-how" of electrification involves many separate applications of C-W through their pioneering of engineering development and initiative.

The complete line of C-W motors made specifically for the steel industry covers every phase of the many steel making processes. They are completely encased in a tight, thick steel housing, larger sizes are force ventilated which keeps out all dust, dirt, abrasives, steel chips and filings. Vacuum impregnation with high grade varnish further protects the windings from corrosive fumes and other harmful conditions.

Each C-W motor and generator is liberally designed with the highest engineering skill and built with proven manufacturing integrity for the specific task it is called upon to perform. Let the C-W engineer solve your problem created by today's needs or your reconversion plans. Let us work hand in hand—to make the steel roll faster...faster!

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JOSHUA HENDY IRON WORKS

CROCKER-WHEELER DIVISION

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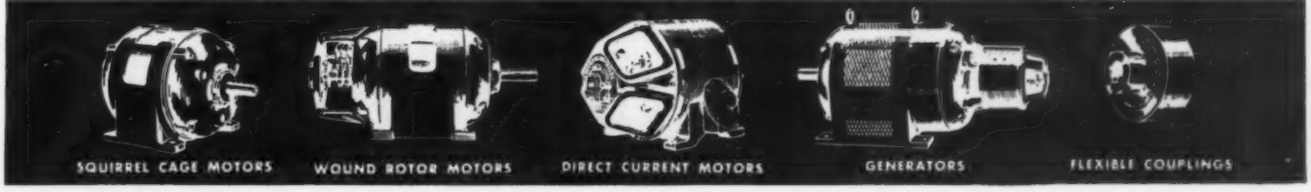

"Without fear of contradiction we state that this instrument, with its continuous balance principle, marks the greatest advance in industrial instrumentation since World War 1"

A NEW PRINCIPLE IN INSTRUMENTATION

Introduced in 1941 as a flight recorder for testing army and navy aircraft, and since limited largely to direct war projects, the Brown *ElectroniK* Potentiometer is now available in increasing quantity to general industry. Without fear of contradiction we state that this instrument is the greatest advance in the art of industrial instrumentation since days of World War I.

Used with conventional wiring and thermocouple installations, the Brown *ElectroniK* Potentiometer is rapidly outmoding all other forms of temperature controllers in the petroleum and other process industries.

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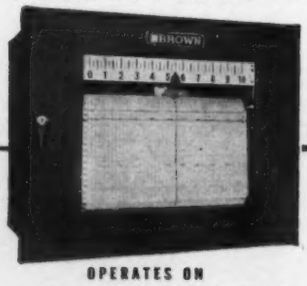

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Advantages that facilitate maximum mill output—

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On LARGE and small mills of just about every type—rolling all kinds of steel and non-ferrous metals, GATKE Moulded Fabric Bearings *minimize interruptions and delays.*

Increased production thus achieved *costs nothing extra.* In fact, additional economies effected by GATKE Bearings—*reduced maintenance expense—tremendous power savings —elimination of grease and greasing costs*—make the use of conventional bearings downright wasteful.

The *sooner* you start using GATKE Bearings, the *sooner* you will *put an end to needless grief* and *start making plenty of extra profit* for your company.

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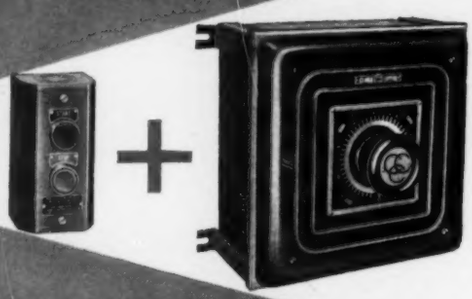
For Roll Necks, Universal Couplings, Spindle Carriers, Table Rolls, Cranes, Acid Resisting Service, and Other Tough Jobs.

"3C" PUSHBUTTON plus RHEOSTAT plus STARTER



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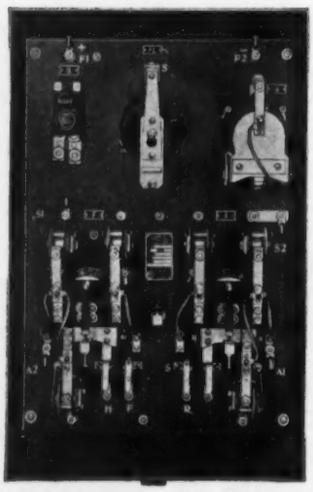
CLARK BULLETIN 5370 Heavy Duty Automatic Starters are available in a wide range of types and sizes for use with shunt or compound wound D. C. Motors where frequent starting is required. Standard catalog listings include starters for constant speed and adjustable speed motors, either non-reversing, non-reversing dynamic braking, or reversing dynamic braking. Many modifications can be made to any of these standard listed starters to meet your particular requirements. The modifications include the following additions:



Bulletin 5370, Size 2, Type RB, Form 2L, Reversing Dynamic Braking Starter

Field loss relays to prevent motor run-away if the field becomes de-energized.

Field accelerating relays to short out the field rheostat during starting.

Field decelerating relays to protect the motor from flash-over when the field rheostat is turned from fast to slow.

Inching relays to provide necessary circuits for inching or jogging operations.

Auxiliary control relays—Electrical Interlocks, etc. to prevent false operation, to provide safety features and to fulfill other such requirements.

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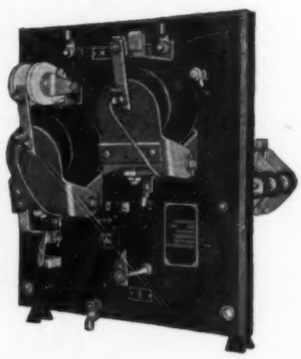

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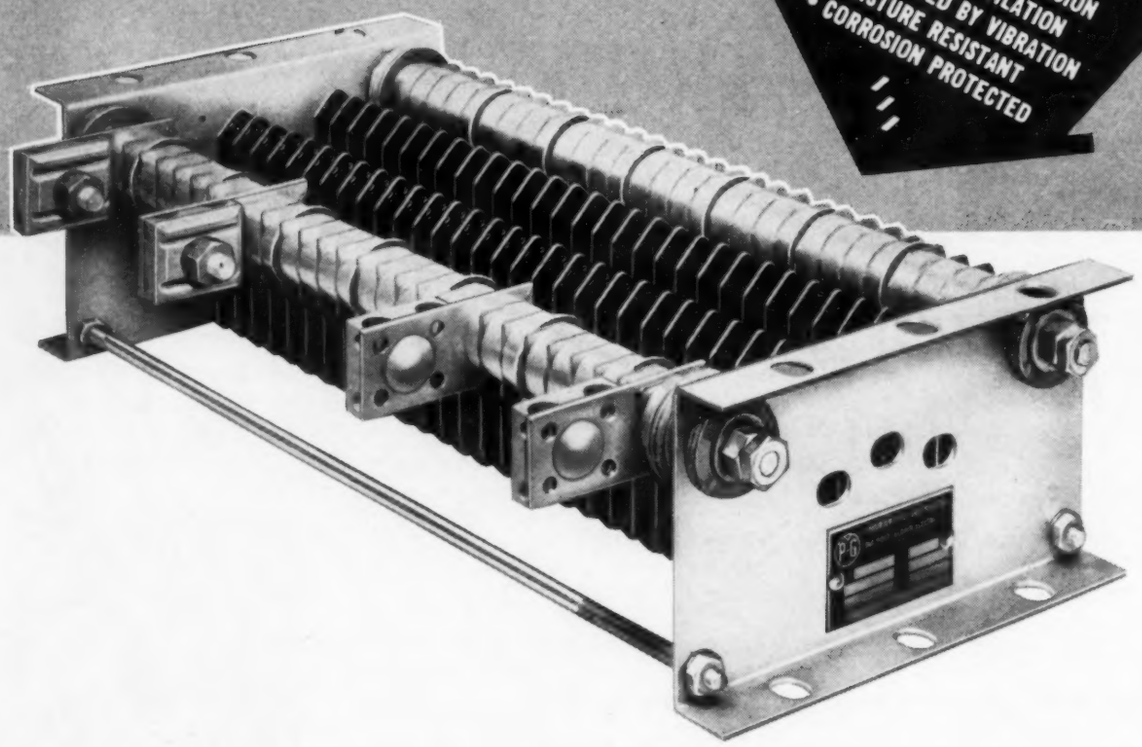

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BIRMINGHAM -- Monday, January 29, 1945

"Aluminum During the War and After," by Dr. Paul V. Faragher, Metal Products Specification Department, Aluminum Company of America, Pittsburgh, Pennsylvania.

BUFFALO -- Tuesday, January 16, 1945

"Rectifiers in the Steel Industry," by F. Mohler, Industrial Engineering Division, General Electric Company, Schenectady, New York.

CHICAGO -- Wednesday, January 3, 1945

"Electric Gauges — Their Operation and Applications," by H. P. Kuehni, Engineer, General Electric Company, Schenectady, New York.

CLEVELAND -- Monday, January 15, 1945
YOUNGSTOWN -- Tuesday, January 16, 1945

"Rotating Regulating Systems," by A. W. Kimball, Design Engineer, Motor Equipment Division, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

DETROIT -- Tuesday, January 9, 1945

"Process Control in the Production of Low Carbon Sulphur Steel," by George Ferris, Openhearth Control Metallurgist, Ford Motor Company, Dearborn, Michigan.

PHILADELPHIA -- Saturday, January 6, 1945

"Imagineering in Switchgear," by D. I. Bohn, Electrical Engineer, Aluminum Company of America, Pittsburgh, Pennsylvania.

"Advantages Gained by Rectifier Installation at Alan Wood Steel Company," by A. D. Howry, Plant Electrical Engineer, Alan Wood Steel Company, Conshohocken, Pennsylvania.

PITTSBURGH -- Monday, January 8, 1945

"Overload Protection for D-c Mill Type Auxiliary Motors," by B. Starie, General Electric Company, Schenectady, New York.

"Developments in Switchgear Engineering during the War Period," by M. H. Hobbs, Manager, Switchgear and Control Engineering, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

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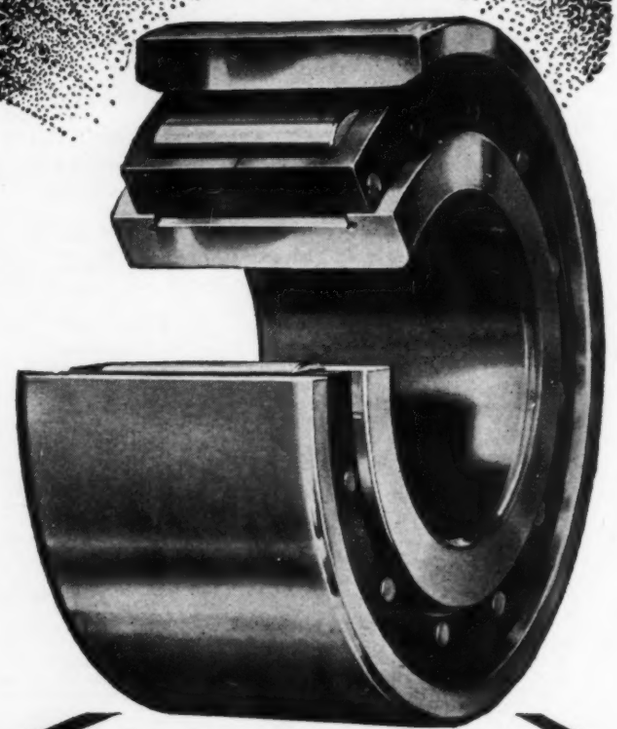

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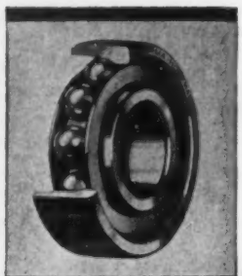

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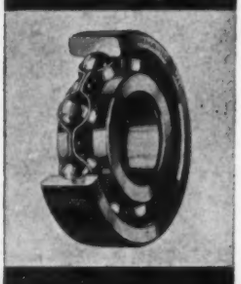

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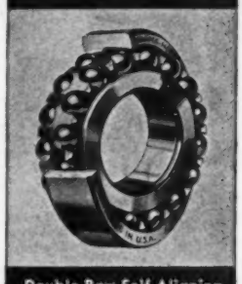

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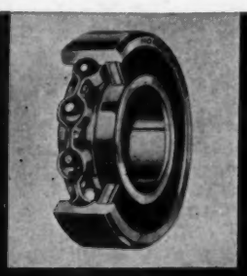

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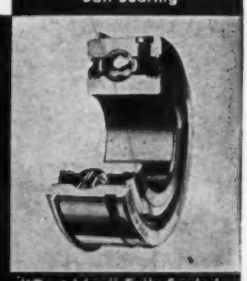

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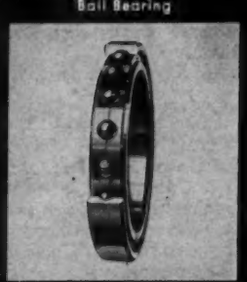

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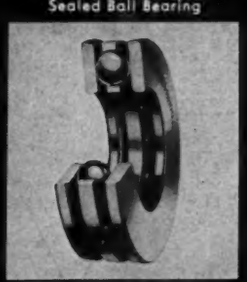

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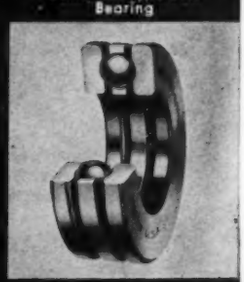

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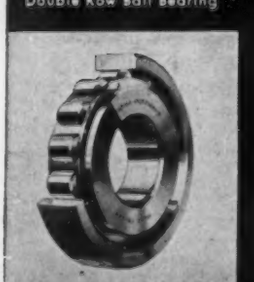

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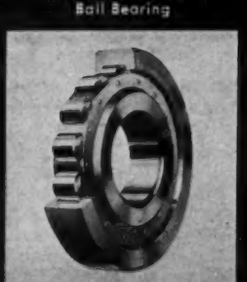

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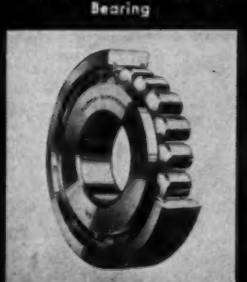

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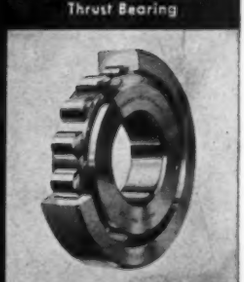

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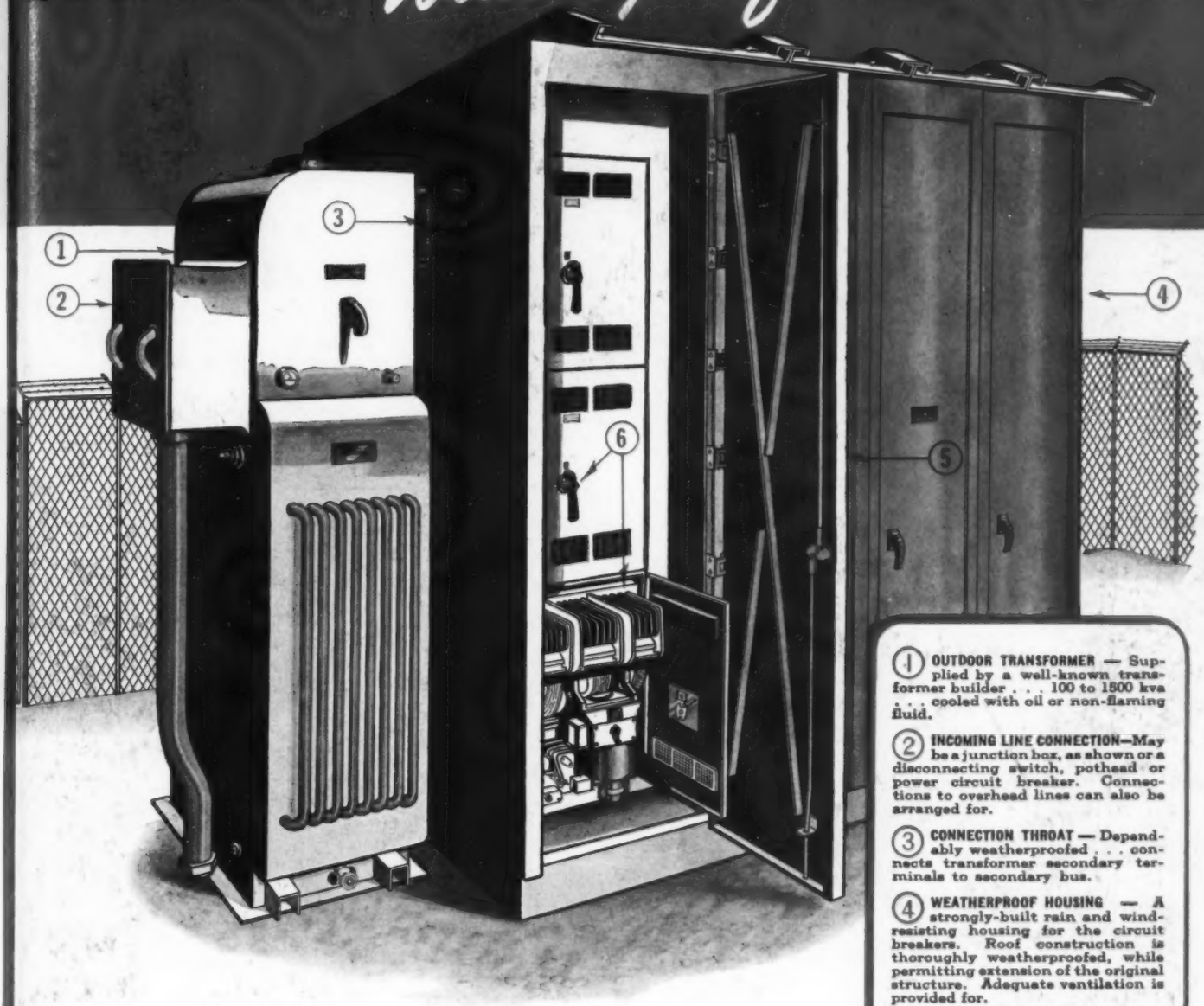

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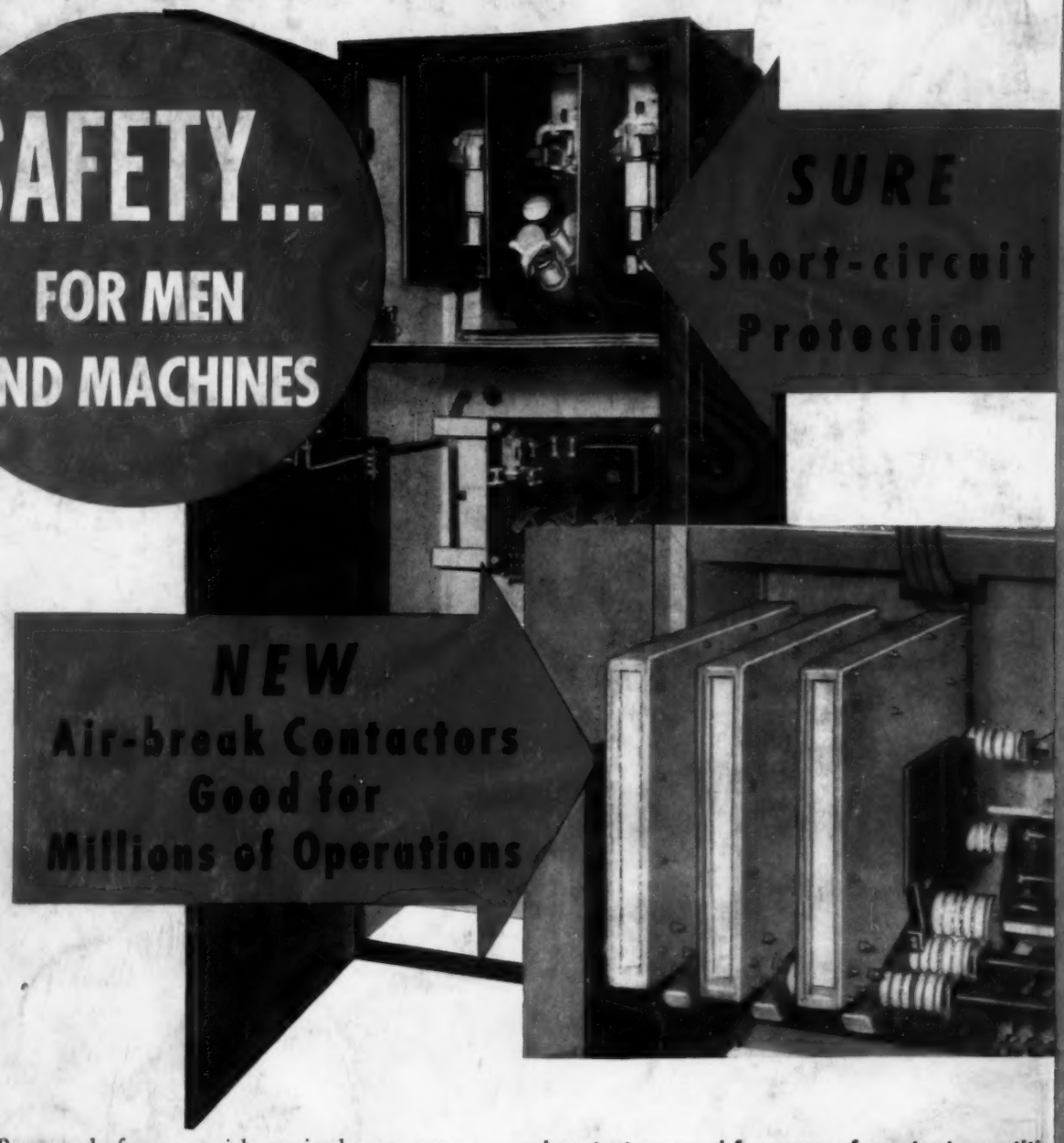

LIMITAMP control, for use with squirrel-cage, synchronous, and wound-rotor motors, has an interrupting capacity more than adequate for installation on most industrial power circuits.

Plant Equipment Protection—The Type EJ-2 fuses in this control give your electric equipment the fast, positive, short-circuit protection so necessary for safe operation on high voltages. They operate in a split cycle. When a short occurs, they cut off the rise in current in less than a quarter cycle, and clear it in less than a half cycle—long before the short-circuit current has had time to harm the contactors or motor.

Personnel Protection—Totally metal-enclosed controllers give protection to operating personnel. High-voltage circuits are completely segregated. All high-voltage equipment is mounted in the upper and rear compartments, and all low-voltage equipment is mounted in the front compartment.

—and contactors good for years of constant, repetitiv service. The full short never passes through the con tactors. Therefore, the contactors, which are air-break are designed to meet the most severe requirements o high-voltage motor-control service. Mechanical life o several million operations, and contact-tip life man times the life of comparable oil-immersed tips, make thes air-break contactors the logical answer for any sever duty—in steel mills, rubber mills, etc.

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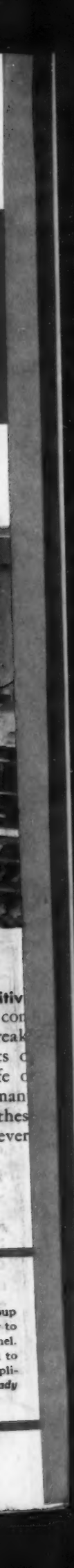
all about this motor control. How a group of these starters can be fitted together to give you a neat, compact control panel. Our local sales engineers will be glad to help you select a control to fit your application. *General Electric Co., Schenectady 5, N. Y.*